Third International Conference on Geotextiles, 1986, Vienna, Austria

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RECOMMENDATIONS ON THE USE OF PLASTIC MATERIALS IN FOUNDATION AND HYDRAULIC ENGINEERING

EMPFEHLUNGEN FÜR DIE ANWENDUNG VON KUNSTSTOFFEN IM ERD- UND WASSERBAU

RECOMMANDATIONS POUR L'USAGE DES MATERIAUX SYNTHETIQUES DANS LE GENIE CIVIL ET LE GENIE HYDRAULIQUE

The history of development concerning the use of plastic materials in the foundation and hydraulik engineering ist only about 30 years old. Present-day knowledge in this field, however, is relatively large, especially when one considers the long period of time during which experiences with commonly used building materials evolved. This will be illustrated by the way of a number of introductory sentences.

1. Introduction

Whenever we find that in a particular scientific discipline:

- the historical development,
- the theory and research arising therefrom, as well as
- knowledge, experience and
- their evolution into the sphere of practical application

form a complete entity, we are once again confronted with the harmonic course of a "living" process. The evolution of life on our planet undoubtedly represents the most perfect example of this (1).

In the problem which is to be presented, we are dealing with the question of balance in a development, which, on the one hand is relatively simple to describe due to the short period of time involved, and on the other hand has extremely complicated characteristics owing to the absence of a harmonic course, as governed by the latter.

Unless it has not already become clear to one individual or the other in past Congresses, it should at least become clear during this year's Congress that to us specialists, who understand something about plastics, a certain philosophy is lacking, ie. a philosophy which should, above all else, lead to:

- a counterbalance to make up for the lack of a developmental history and the
- closing of gaps in the theory and research.

By this means, it will be possible to generate the harmony about which I have already spoken, despite a stormy and partly overpowering development. In this sense, the specialist topics of today's Congress are of particular importance, since it is with these that the onward leading steps will be taken, namely:

- An exchange of knowledge and experience, and
- the consequences arising therefrom for the evolution into the realm of practical application

The "Recommendations on the use of Plastic Materials in Foundation and Hydraulic Engineering" have been developed by a continually growing and to some extent newly formed group of specialists since 1973. The latter comprise the Working Group of the German Earthworks and Foundation Engineering Association, which in the meantime belongs to the Specialist Working Group of the German Federation for Water Resources and Drainage Engineering Inc. (DVWK).

The "Recommendations on the use of Plastic Materials in Foundation and Hydraulic Engineering" have recently appeared in the publication "DVWK-Regulations in Water Resources". This constitutes a comprehensive publication, which is based upon articles from 1975, 1979 and 1982 (2, 3, 4) and which also contains an evolution of previously available investigation results and includes practical experience (5, 6).

As a number of specialists belonging to the working group have agreed to give personal reviews at this Congress, specific areas of interest from the wide spectrum of field-related topics which are mentioned in the "Recommendations", will be touched upon.

The objective of my paper is to inform you of the material contained in the "Recommendations" in such a way that the knowledge acquired during its development is predominant. Alongside the essentially technical information, the latter constitutes a starting point for developing the desired philosophy which I have already outlined. In this respect , I have devived the following statements, which form the cove of such knowledge.

2. GUIDELINES FOR THE PROTECTION OF SOILS SUBJECT TO EROSION

1. The demands to be placed on geotextiles depend upon the anticipated function and the characteristics of the particular area of application. The long-term durability must be sufficient in relation to the ambient media and characteristic loadings.

   Installation of the geotextile without damage must be ensured, with respect to both constructional considerations and installation methods. In certain circumstances, a protection layer must be provided.

2. In evaluating the long-term durability of geotextiles, it should be especially noted that the probability that a fibre or thread will be damaged decreases with increasing thickness, since the outer layers subject to attack protect the core. For almost all raw materials used, limitations must be conceded with respect to one or another proberty in order that the correct choice ist made in relation to the specific requirements of the proposed area of application in a particular case.

3. In using geotextiles as filters and separating layers, it is necessary that the pore structure is correctly matched to the grain sizes to be held back in the soil being protected (mechanical filter effectiveness). A characteristic value to describe the coercive properties of the soil is the so-called effective opening size D_W.

   In selecting the material for the filter layer, naturally-induced conditions apposing the mechanical filter effectiveness (coercive properties of the soil) and the hydraulic filter effectiveness (pressure-free drainage of seepage water) must be fulfilled.

4. If it is not possible to make a sufficiently accurate estimate of the acting forces (hydrostatic/hydrodynamic pressures) and the flow velocity, careful measurement of the mechanical filter effectiveness is recommended. Reliable estimates allow for high hydrostatic/hydrodynamic loadings of the soil-filter system. hydraulic pressures which may occur must be accomodated by the entire construction without damage.

5. Static loadings result from quasi-stationary boundary conditions for the flow in the filter layer. This occurs for long-period fluctuations in the free-surface and groundwater levels with small hydraulic gradients an laminar flow conditions. Following an initial phase, no further significiant rearrangement of grains in the boundary layer geotextile/soil takes place.

6. Textile fabrics are suitable for static loadings particularly when applied on uneven soil, since a stable secondary filter generally develops in this case. If high demands ar places on the filter effectiveness, fabrics with high slip resistance should be employed.

7. Dynamic loadings are charcterized by short-period alternating flow directions and turbulent flow attack on the filter layers. They occur, for example, on wave-loaded surfaces associated with coastal protection structures or on revetments and bed coverings of inland waterways. For dynamically loaded filters, the boundary condition for a self-developing secondary filter is not generally given.

8. In order that a geotextile is hydraulically effective, its permeability should equal to or greater than that of the outcropping soil following formation of the secondary filter in the boundary layer geotextile/soul. This is necessary in order to ensure that the accumulated seepage water may be removed through the geotextile with as little pressure as possible. As in the case of mineral filters, an unavoidable reduction in the permeability of the pure geotextile accurs due to contact with the soil (fine pariticle embedment, depth filtration).

9. Under the requirement that long-term permeability must be ensured, it should not be noted that the permeability coefficient can be partially reduced due to blockage of the fabric pores by the determination of a reduction factor for the permeability coefficient.

10. Due to the pressure of surface loading, the effective opening size for non-woven fabrics is reduced. The simultaneous reduction in the permeability may be determined by appropriate laboratory tests. In evaluating the long-term permeability, it should be noted that the permeability coefficient reduces due to the migration of soil particles into the non-woven fabric (clogging). First approximations are available to estimate

this effect.

11. In order to achieve a drainage effect, permeability in the plane of the geotextile filter is also necessary. For this purpose, only thick non-woven filters may thus be used.

The permeability in the plane of the fabric may be calculated by way of the transmissivity as the product of the permeability coefficients in the geotextile plane and thickness, each being functious of the surface loading.

12. As for mineral filter layers, the thickness and gradation of geotextile filters have a significiant influence on the long-term mechanical and hydraulic filter effectivenesses. A larger overall thickness of the layers is necessary for larger loading requirements.

In the case of composite materials, the advantageous properties of individual geotextiles can be combined together. Composite materials are comprised, for example, of a fine filter layer, a pre-filter layer of lower fibre quality, and depending upon the particular application, a stabilization layer, which improves the degree of soil contact by virtue of its roughness.

13. Problem soils may be considered to be those which contain a significant proportion of silt and fine sand. Owing to the very low cohesive properties of such soils, high mobility of individual grains may be expected with an increase in loading requirements.

14. Problems of filtering may also occur for soils which exhibit a highly partitioned grain-size distribution in which certain grain-size ranges are absent. For such soils, attention must be paid to suffusion safety, which refers to the flushing of fine particles from the coarse soil skeleton.

15. In the application of geotextiles for stabilizing and strengthening revetments and as filters in drainage works, confirmation of the hydraulic filter effectiveness is necessary since this has a governing influence over the stability and functional behaviour of the structure.

3. GUIDELINES FOR PRODUCING SEALS

1. The work involved in producing seals should be carried out by experienced and competent firms. The sealing work must be conducted in such a way that the seal, including possible connections to the structure and connecting seams, must form an entirely sealed layer with sufficient strength and deformability. In carrying out this work, installation procedures given by the manufactures for the particular materials used must be complied with.

2. Supervision during the installation of plastic sealing joints embraces all areas of activity on the construction site. Items which should be particularly checked are:

   - Evenness and load-bearing capability of the ground surface,
   - careful delivery and intermediate storage of the sealing material in order to avoid damage or loss of quality,
   - correct laying of the sealing strips, particularly along joints and protrusions as well as,
   - flawless installation of protection layers.

3. If, during excavation and foundation laying work, discrepancies are observed between construction plans and actual site conditions, the suitability of the site should be re-examined and appropriate measures taken where necessary.

4. It is essential to consider not only the general requirements of the materials used, but also to determine the effective loading factors for a concrete case of applications. If it is not possible to make sufficiently accurate estimates of the loadings expected, in exceptional cases, acceptable estimates must be given sufficient safety margins.

5. The required friction coefficient is dependent upon the particular case of applications. In any event, it must be ensured that the friction coefficient of the sealing strips relative to the ground surface or bottom covering layer is larger than that relative to the outer covering layers.

6. In assessing the mechanical behaviour of plastic sealing strips, both "deformability" and "energy absorption capability" must be considered. Depending upon the case in question, these characteristic values may be of differing importance.

7. The time-, temperature- and stress-dependent increase in deformation may be described by the creep behaviour, the requirements of which will differ according to the particular case of application.

8. In the case of single loadings, it must be shown that the maximum permissible deformations are not exceeded due to creep. This holds, for example, for the case of the dead load on revetments, unless this is resisted by friction on the bed layer or by attachment to solid structures.

9. Sufficient perforation resistance (mechanical penetration strength) should cover punctiform loadings, especially during the construction phase. In relation to this, the high rate of deformation, which may arise from such loadings, must be considered in the testing procedure.

10. Sealing systems with plastic sealing strips are comprised of different layers, which, in the simplest case (from the bottom to the top) consist of

- supporting layer
- sealing layer and
- protection layer

11. The supporting layer or fine surface layer forms the base for the sealing strips. This layer should prevent impermissible mechanicel loading and should provide for steady loading. In relation to its thickness and coarseness, these must be matched to the sealing strip.

12. If the sealing layer is not able to fully resist the wear and tear on the surface of the sealing elements, this must be provided with a protection layer. Such wear and tear may take the form of ultraviolet light, heat, frost, ice movement, sand abrasion and loadings due to movement of people or traffic as well as to non-uniform loadings.

13. The minimum nominal thickness of plastic sealing strips is 2,0 mm. The nominal thickness increases above this value in steps of 0,5 mm. The maximum permissible deviation of the mean from the nominal thickness is ± 5 %, whilst for the smallest single value, a 10 % deviation is permissible.

14. With regard to the connection of the sealing strips, the same requirements apply as for the sealing strips themselves. In any event, the joints must have a durable seal and must be produced and configurated in such a way that they can transfer all mechanical loadings which may occur in the sealing strips. The strength of the joints is generally represented by a welding factor for plastic sealing strips.

15. The strain and connection elements should as a rule be installed in recesses shortly before commencing the sealing work. Concreting-in of the sealing strips in the initial pur is not permitted, since subsequent repair of damage is virtually impossible. In contrast, the concreting-in of connection elements is permitted. It should always be noted that in the case of connection constructions, cold flow can occur and that compatability between the jointing material and the sealing elements is ensured.

4. Outlook

By way of the above-mentioned guidelines, I have attempted to show that special basic rules apply in the design and construction with plastic materials, which, although naturally related to those adopted in the use of common building materials, also have important differences. If I have succeeded to demonstrate this fact, then my mission today has been accomplished. If so, I may therefor assume that my thougths arising out of 30 years of experience concerning the use of plastic materials in foundation and hydraulic engineering have played a part in passing on to you the results relating to the development of recommendations by a group of specialists based upon a "philosophical" viewpoint.

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