Efficiency of Synthetic Geocomposites as Vertical Drains

R. Baslik
Civil Engineering Research Institute, Bratislava, Slovak Republic - Czechoslovakia

Z. Cerná
Research Institute for Textile Chemistry, Zilina, Slovak Republic - Czechoslovakia

ABSTRACT: In the article a investigation of the various phenomena which influence to the drainage geocomposite efficiency used on a surface of the underground rigid basements is presented. The one geocomposite type was selected and tested. The long-time tests of the thickness and permeability with the different pressure were carried out. Influence of the soil pressure distribution, direction and velocity of groundwater flow, changes of the thickness and degree of saturation of the drainage system on its efficiency are determined.

1 INTRODUCTION

Synthetic geocomposites are being increasingly used in Slovakia for vertical drainage behind retaining walls, bridge abutments, basements and other engineering structures. The artifical drainage products replace traditional granular filters and drains successfully.

The investigations some of the factors which affect geocomposite drainage were performed in the laboratory to get a better understanding of that product.

This paper deals with the effect of thickness reduction, geocomposite anisotropy and degree of saturation with respect to drainage behaviour.

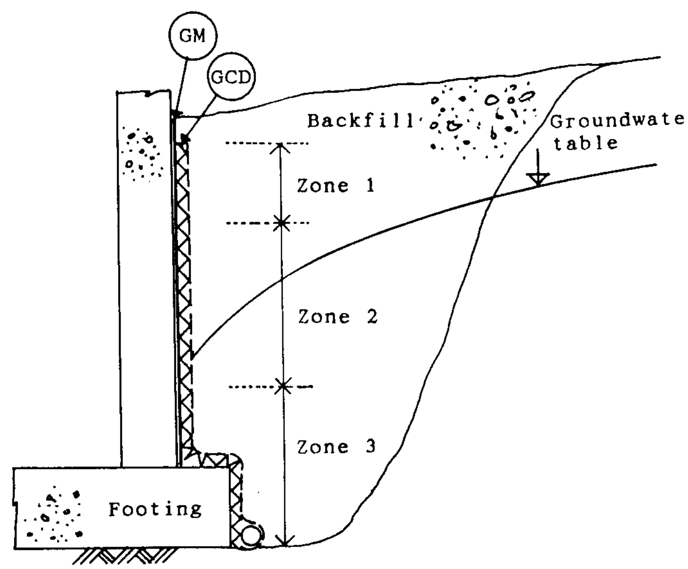

Fig. 1 Geosomposite drain for basement

2 DRAINAGE GEOCOMPOSITE AS VERTICAL DRAINAGE

Geocomposite drain (GCD) is suitable for use at greater depths, e.g. in the case of the deep basements (Figure 1). GCD relieves hydrostatic pressure occuring in surrounding soil and transports water to the drain pipes.

One type of GCD named TERRADREN 1 manufactured by Tatraľan Kežmarok was used in this research. This product is a three-dimensional composite which consist of a nonwoven geotextile fusion bonded to the drainage layer (Figure 2). The drainage layer is composed of tough, looped, continuous polypropylen filaments which form open-structure.

In respect to two important boundary conditions, namely the state of stress of adjacent soil as well as groundwater velocity and direction of flow, three zones are appeared in the backfill (Figure 1). The upper zone 1 is characterized by the low constant

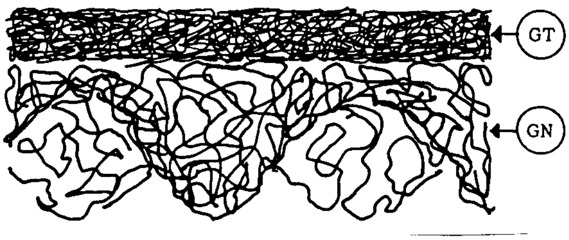

Fig. 2 Geocomposite drain

earth pressure (additional load on the ground surface is possible). GCD transports only rain water infiltrated from the ground surface. The middle zone 2 is characterized by the higher earth pressure and primary changes of the hydraulic gradient, flow velocity as well as direction of groundwater flow. Lower zone 3 is characterized by the high lateral earth pressure and the stable groundwater flow through both the pores of the soil and pores of the geotextile.

The presence of an unstable conditions within zone 2 can cause the design difficulties. Therefore a large attention was devoted to this zone.

3 TEST RESULTS

3.1 Effect of applied earth pressure

GCD attached to the basement or the wall must be capable of withstanding high earth pressures. These pressures result in the reduction of the geocomposite thickness. In order to assess the thickness decrease with increasing normal stress above mentioned geocomposite was evaluated. The response is given in Figure 3.

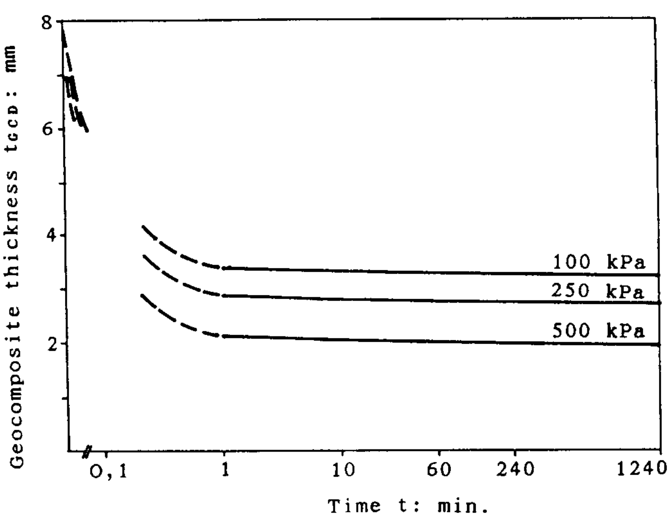

Fig.3 Compressibility of geocomposite drain

From Figure 3 it may be seen that when pressure is increasing then the geocomposite thickness decreases expressively. Soil pressure deforms the geotextile into the geonet. This intrusion clearly decreases the permittivity of GCD as well as its transmissivity. Figure 4 shows typical relationship between coefficients of permeability of GCD and applied normal pressure.

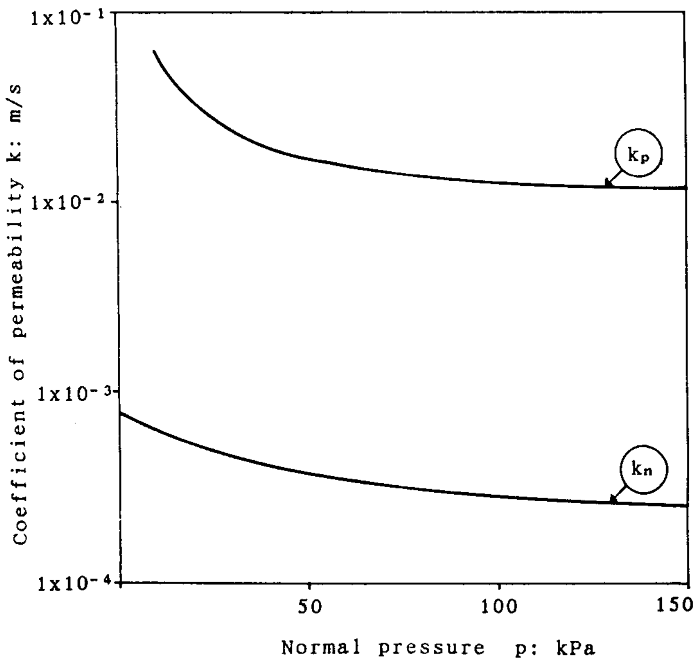

Fig. 4 Flow rate vs. normal pressure curves of GCD

GCD has much higher coefficient of permeability in the plane (upper curve) than coefficient of permeability normal to the plane (lower curve).

3.2 Effect of GCD saturation

The voids between the solid particles of adjacent soil as well as the voids between fibres or filaments of the nonwoven geotextile within zone 2 are filled with fluid - either water or air or a combination of the two. Degree of saturation of the soil and geotextile is unstable and it directly influences the GCD performance (Gourc, Faure, 1992) in zone 2.

Combine test on the permeability of GCD to water was carried out with the aim better to understand this problem. Let us introduce the term of relative permeability of GCD. Figure 5 shows coefficient of permeability vs. time curve.

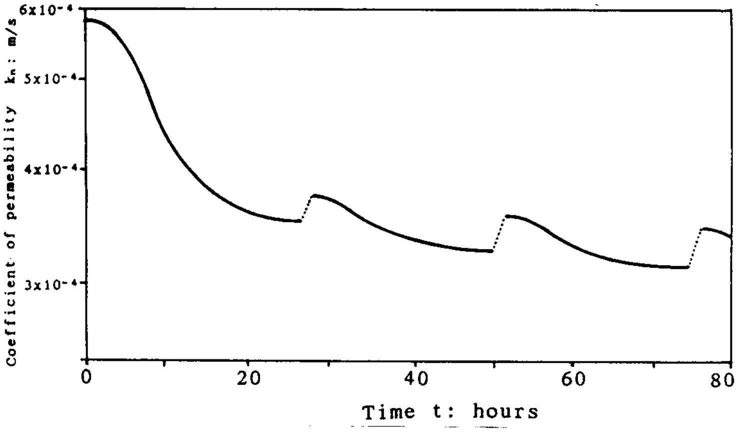

Fig. 5 Effect of S_r on GCD permeability

The specimen is placed in the permeameter and loaded to the normal stress of 150 kPa. The specimen is not saturated with water in advance. During testing, the water flowed across the specimen in the 1-day intervals. The water was flow out from the permeameter at the end of the each flow-interval. The inclination of the test curve shows that the air is pushing out from the geotextile rapidly, it may be expected the stable conditions of the permeability after short time.

4 WATER FLOW THROUGH GCD

The flow of water through the GCD is influenced by the discharge capacity of the drain layer as well as by the permeability performance of the bonded geotextile. If we consider the relationship between the coefficients of permeability as follows: $k_s < k_{gt} < k_{gn}$, then the flow net in Figure 6 is valid.

At a boundary between materials with different permeabilities, the stream lines are deflected. Thus the water flows along a longer length in the direction of flow within the more permeable materials. The inclinations of the stream lines are depended on the coefficients of permeability of the materials on both sides of the boundary.

It must be remembered that the nonwoven geotextile is anisotropic material. The geotextile anisotropy is represented by means of the relationship k_n/k_p. These relationships for the nonwoven geotextiles of different weights are shown in Figure 7.

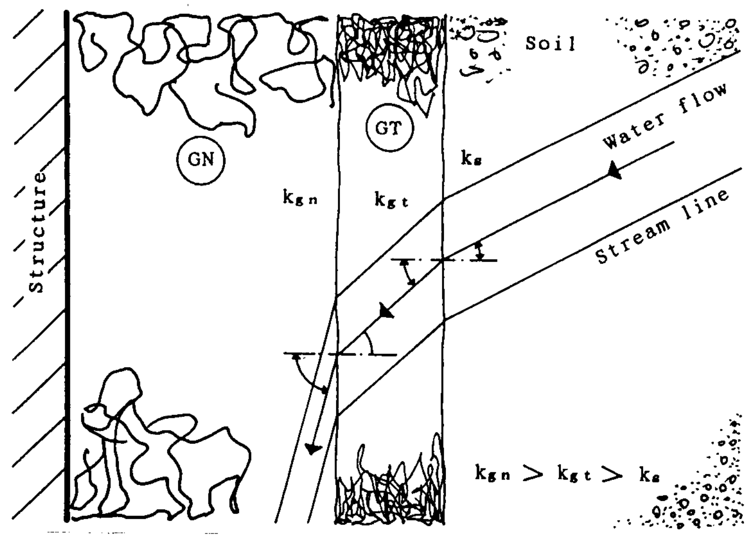

Fig. 6 Stream lines at the boundary of the different materials

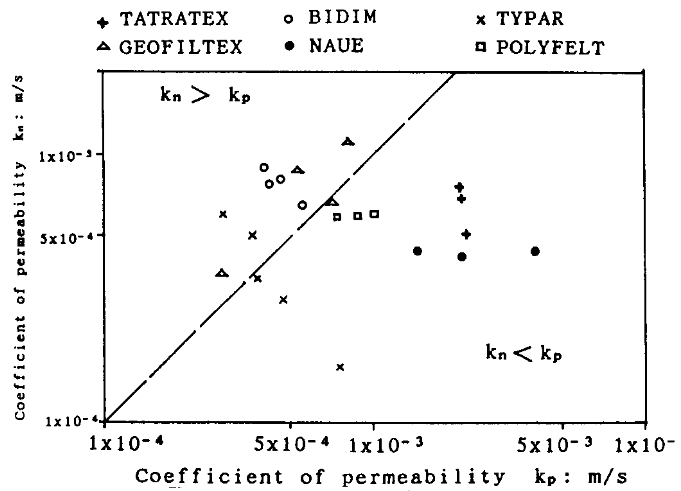

Fig. 7 Geotextiles anisotropy

In-plane permeability of the thick nonwoven geotextiles is higher than that of the woven and heat bonded ones (Gerry, Raymond, 1983). The geotextile permeability depends on its weight too. In considering of the inclined direction of the movement of water in the geotextile (Figure 6) it is necessary to take into the GCD design the value of k which occures between values k_n and k_p.

5 CONCLUSIONS

The evaluation of some factors which influence the performance of geocomposite drain attached on the basement was performed. Both the tests and the analysis carried out resulted in the following conclusions: 1. In respect to important boundary conditions three zones was appeared in the backfill. The most complicated is the middle zone. In consequence of the groundwater table fluctuation, hydraulic gradient, flow velocity, flow direction and degree of saturation are varied. 2. The laboratory tests show that GCD thickness and its coefficients of permeability k_n and k_p decrease expressively by increasing of the lateral pressure. 3. Both the degree of saturation of GCD and that of surrounding soil influence the GCD permeability in the first stage of the water flow. 4. The flow net form depends on anisotropy of geotextile bonded to the core of geocomposite. For designing the geocomposite drain performance it is suitable to consider not the coefficient of permeability normal to the geotextile plane but the average value between values of k_n to k_p.

REFERENCES

Gourc, J.P. and Faure, Y.-H. (1992) Soil particles, water... and fibres - A fruitful interaction now controlled, *Proceedings of 4th Int. Conf. on Geotextiles, Geomembranes and Related Products*, A.A.Balkema, 3:949-971.

Gerry, B.S. and Raymond, G.P. (1983) The in-plane permeability of geotextiles, *Geotechnical Testing Journal*, 6:181-189.