GASPAR, L., Institute for Transport Sciences (KTI), Hungary
OROSZLAN, M., SCHNEIDER, A., TEMAFORG, Hungary

HUNGARIAN EXPERIENCES WITH GEOTEXTILES IN HIGHWAY CONSTRUCTION

UNGARISCHE ERFAHRUNGEN MIT DER VERWENDUNG VON GEOTEXTILIEN IM STRASSENBAU

EXPERIENCES HONGROISES AVEC DES GEOTEXTILES POUR LA CONSTRUCTION ROUTIERE

Since 1972 geotextiles have been used in Hungarian highway construction mainly for the foundation of embankments and for temporary roads on subgrade with low bearing capacity. Chapter 1. summarizes the experiences connected with the forementioned topics. While chapter 2. describes the Hungarian Temporary Directives compiled above the actual method. Chapter 3. supplies information about new Hungarian products and procedures, namely:TEMISOL-plates, cheap geotextiles produced of regenerated textile cuttings, TEMADRAIN with spiral skeleton, biological slope protection, textile container for plants.

1. HUNGARIAN EXPERIENCES

1.1. Foundation of embankments

Large road embankments on compressible soils are constructed in Hungary mainly with geotextile foundation. (1).

In such a way - among others - on the corrected 2 km long section of road No. 71 on the northern shore of Lake Balaton 36 ooo sq.m French BIDIM geotextile was laid where soaked peat in the depth of 1,6 to 4,6 m presented itself. The lower 1,2 m layer of max 4,6 m embankment was made of sandy gravel and the rest of it was constructed from locally available silty soils. Settlements were regularly measured in three cross-sections with placing and sounding 3 plates each. Figure 1. shows that the settlements increase proportionally with the mass of embankment.

In 2 to 3 months time after the completion of earthwork the quick part of settlement of about 1oo cm developed practically completely: the consolidation curve was smooth. There was a relativ good agreement between the precomputed and the measured settlements. Secondary slow settlement - as a function of embankment height and peat thickness - were between the forthcoming 17th to 37th months as follows:

Embankment height	Peat thickness	Settlement
1,o-1,8 m	4,7 m	1o,o cm
1,8-2,9 m	3,5 m	7,2 cm
2,9-3,7 m	2,8 m	6,5 cm
3,7-4,6 m	3,7 m	1o,9 cm

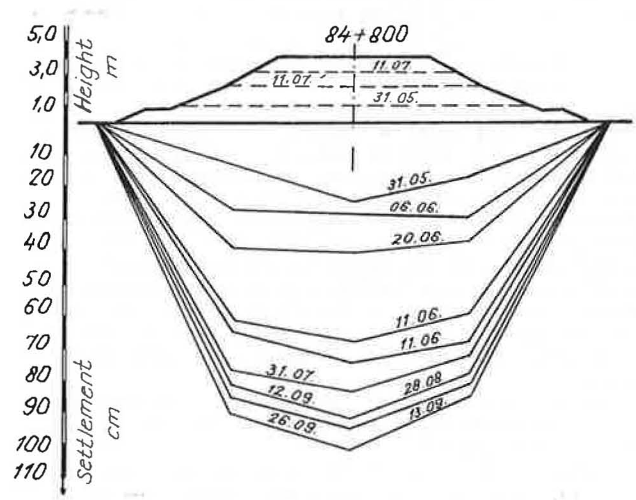

Figure 1. Actual level of settlement measuring plates in the course of measurements

On a pile founded bridge of 15 m span the settlement of adjoining embankment amounted to 15 cm in the first year and 7 cm in the next 2 years. The differential settlement has been so far several times corrected by asphalt overlaying. The condition of highway section is still good just now.
According to the results of control measurements the natural watercontent of peat was reduced in two years from the original 285-56o %, the effective internal friction angle increased from o-2^{o} to 4-11^{o}, while the modulus of compression from 7-1o kPa to 14-3o kPa.
On the swampy soil of the new factory railway station of Budapest City Transportation Firm 6o ooo sqm Hungarian geotextiles typ F 6o1 and TERFIL I was laid. Using this method the planned construction time could have been halved and a significant cost saving has been attained. Similarly recently geotextiles typ TERFIL were laid into some soaked clay cuts of motorways M 1 and M 3, in this way huge subsoil changing could be avoided (2).
A relative long correction section of main road No. 36 runs on a swampy area. Cut-off willow and poplar trunks were first covered with silty coarse sand layer and then geotextile was spread over it. Then drainage course and fly ash embankment followed.

1.2. Other application areas

Some other experiments have proved that geotextiles can be used not only for foundation of embankments but on other areas too. Some examples for it:
- temporary work site and transport road construction,
- foundation of asphalt pavements,
- bearing capacity increasing of weak pavement constructions,
- widening of too narrow pavements,
- drainage of railway bedding,
- replacement of filter layers in drainage pipes,
- erosion protection,
- stability increase of soil slopes,
- foundation of sport or parking places etc.

Some Hungarian examples:

The top 6o-7o cm part of peat in Hanság is an organic black clay. Originally the forestry roads were constructed here using 2x3o cm gravel layers, as base course. In October 1973 a pavement structure of sufficient bearing capacity was built LINZ PP-VLIES with about 2o cm gravel layer.
In 1975 by Kápolnásnyék a temporary road and a stage were to be constructed on peaty soil for an auto crane that was supposed to transport the prefabricated elements of a large bridge. The foundation of FIBERTEX - geotextile seemed to be the most advantageous from the point of view of construction time and costs. After the completion of work the textile could be recovered.
In 1975 by Apátfalva FIBERTEX filled with bituminous emulsion was spread on an about 3 km long highway section and agricultural road, instead of the planned sandy gravel protection layer and crushed stone base course.
Bituminous base and asphalt pavement were constructed on it. The condition of this pavement section is still at present favourable.
By Dombóvár, Sávoly and Szentlörinc textiles type FIBERTEX, BIDIM and F 6o1 were spread under railway bedding.
On the section km 6,7-6,9 of main road No. 74 the originally planned deep drain on swampy-rushy area was replaced by using 29oo sqm BIDIM, 2o cm sand and 8o cm sandy gravel.
In county Csongrád FIBERTEX was laid under the asphalt pavement of 4 sport-grounds onto hardly compacted soil.

2. HUNGARIAN TEMPORARY TECHNICAL DIRECTIVES

On the basis of favourable results in 1979 temporary (provisional) directives "Embankment construction with geotextiles" was completed. The mass per unit area and the tension strength lower limits of four geotextile types - satisfying the anticipated requirements - are as follows:

Type	Specific mass	Tension strength
GT-1oo	1oo-17o g/m^2	2oo N/5 cm width
GT-2oo	2oo-27o "	3oo " "
GT-3oo	3oo-4oo "	7oo " "
GT-4oo	45o-55o "	9oo " "

The lower expansion limit in longitudinal direction is 5o%. As a function of presumable settlement the geotextile type and the minimal thickness of granular layer are to be selected as follows:

Settlement	Type	Layer thickness
under 2o cm	GT-1oo	min 3o cm
2o-4o cm	GT-1oo	35-55 cm
41-7o cm	GT-2oo	55-85 cm
71-12o cm	GT-3oo	9o-14o cm
above 12o cm	GT-4oo	min 14o cm

In case of soils with increased deformability and small shear strength (peat, organic bound soil) the higher embankments are built stepwise (e.g. in 1-2 m high layers). Between various loading steps construction breaks of some days - or of some weeks - have to be made in order to decrease the neutral stresses caused by loading and to increase the shear strength of soils sufficiently so that it could bear the load of new embankment heightening with certainty.
After the laying of geotextile comes the spread of the first, at least 25 cm granular material layer using the technique of overturning the material forward.
The first layer should be compacted with transport vehicles suitably directed and with rubber multi-tyred roller passes. The subsequent layers can be constructed according to known directives using soil types suitable for embankments. The settlements are more significant in embankment axis than in the edges, that is why cross fall should be increased by 1o % (s. Figure 1.)

In the course of embankment construction the settlements should be measured (controlled) continuously. When too quick settlement can be observed the construction activity is stopped temporarily.
A special care is necessary where engineering structures an embankment on compressible soil have. In comparison to bridges with deep foundation the embankment has a significantly larger settlement. The method of repeated decreasing of actual steps (e.g. by new asphalt layers) can be judged as disadvantageous from technical and economic view-points. If the construction of such kind of an engineering structure can not be avoided it is advisable to build the adjoining embankment higher by anticipated settlement values so that the level differences in few years can be compensated.
The flexible -from prefabricated elements - culverts or engineering structures on soft subgrade can be laid advantageously.
When designing provisional roads it is advisable to determine geotextile type and the thickness of granular layer according to the values in Table 1 - as a function of underground bearing capacity and of the anticipated traffic volume of road.

When constructing provisional roads the surface of granular layers having not enough resistance to traffic effects because of the lack of fine fractions can be mechanically stabilized spreading sand, chippings, grit or similar material on it in order to improve its passability. After having finished the transportation the built-in materials and geotextiles can be recovered and later used again.

3. NEW HUNGARIAN PRODUCTS

Our Textil Firm, TEMAFORG that since 1976 geotextiles TERFIL I-II-III produces has lately developed and patented the following new products.

3.1. TEMISOL-plate

This plate is produced of thermoplastic plastic wastes mainly polyethylene, polypropylene and polyamide foils. The mixed wastes are cut into narrow stripes, cleaned, compacted into the form of a plate and then in a distance of 15 mm melted through pipelike using needles (3,5 mm diameter) heated on 3oo-6oo °C. Thus the stripes can be transformed without cementation into plate having 15-3o mm thickness and 15o-25o g/m mass per unit area. The length of plates having tensile strength of 7o-16o kPa and compressive strength of 28 kPa, varies between 1 and 5o m, besides this porous material is resistant to

Table 1. Design of provisional roads

Expected traffic volume and traffic	Subgrade bearing capacity					
	CBR~5 (bound soil)		CBR~2 (wet bound soil)		very weak, peaty soil	
	GT	thickness	GT	thickness	GT	thickness
Max. 1o ooo Mg max 1 month	1oo	2o cm	1oo	25 cm	3oo	3o cm
1o ooo - 1oo ooo Mg (max 1o Mg axle load) several months	2oo	3o cm	2oo	35 cm	45o (3oo)	4o cm (5o cm)
Above 1oo ooo Mg (also very heavy vehicles) several months	3oo	4o cm	3oo	45 cm	45o	6o cm

chemicals, cannot be fungused and moulded.
TEMISOL is able longitudinally - even under large pressure - to absorb $2,6.10^{-4}$ m/s running metre water. This high coefficient of permeability can be used to accelerate the vertical leakage of drain ditches, to entrance ground water into collecting drain ditches. Figure 2/a. presents a solution of it.

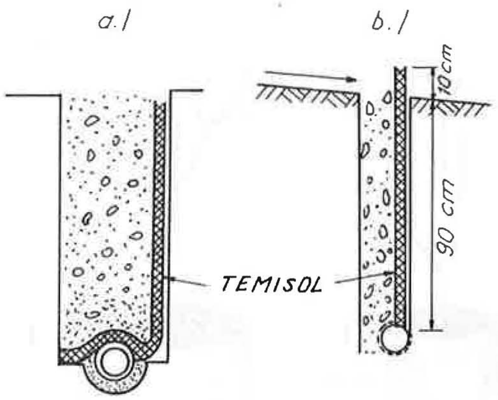

Figure 2. Drain pipe (a.) and drainage cut (b.) with TEMISOL . The sinking ability of filled soil can be increased using treated waste rag.

It can drain the water if placed behind the parts of bulkheads and engineering structures adjoining to soil. For increasing the permeability of TEMISOL-plates also special variants are produced that contain PVC-granulates, jute yarns or foil straw.
TEMISOL when placing into soils with poor water household leads surface waters into deeper layers making thus obstacles to internal water. The cuttings of 15-22 cm wide having vertical walls can be made using ditch excavator or cabling machine, the sinking ability of filled soil can be increased using treated waste rag. On slopes TEMISOL-plate protrudes by 1o cm out of terrain and in such a way it can inhibit erosion damages. The excess water can be led away using pipe placed at the lower part of cutting, as it can be seen in Figure 2/b.

Low-volume - mainly agricultural - earth roads and storage grounds can be made passable all over the year if TEMISOL and silty granular material (mechanical stabilization) of about 2o cm is placed on road subgrade. TEMISOL can not only drain rainwater but distribute loading too.

Its good heat insulating ability makes it possible to apply TEMISOL as partial or total replacing material of frost-protective layers under pavement structures (it is equivalent to a sandy gravel layer of 15-2o cm) as well as to use for the protection of fresh concrete in cold weather.
In construction industry mainly the good heat and sound absorbtion ability of TEMISOL are utilized.
The price of this material is about the same as that of TERFIL geotextile.

3.2. Cheap geotextiles produced of regenerated textile cuttings

For cutting the production expenses geotextiles of several textile wastes are made too. TERFIL F-55 and F-56 are produced using tear of the threads of polypropylene waste, their mass per unit area amounts to 25o g/m and their water permeability coefficient is about 1o l/s. (F-56 is also compacted between rollers). TERFIL F-21 of 3oo g/m mass per unit area contains 8o% shredded mixed acrylic waste and 2o% polypropylene.

These products are cheaper than geotextiles made of new threads by 3o-4o% and they are suitable mainly as filters. The filter effect can be characterized by the quantity of washed-in soil particles: this value for three cheap geotextiles amounts to o,65-o,94 g, for filterless drain pipe with 65 mm diametre to 53,8 g and for TEMISOL to 24,8 g. From the point of view of F-55 density of fibres is the most favourable, while for a finer filtration F-21 can be considered as most suitable.

3.3. TEMADRAIN with spiral skeleton

The specific transportation costs of traditional drain pipes are high and they often require their cover with drain textiles. The skeleton of TEMADRAIN developped by the firm TEMAFORG is ensured by the help of spiral structure produced of plastic wire on which the polypropylene drain textile having 86 Vol% pore content is fixed on the laying site. The specific transportation cost of material does not exceed the 2o% expenses incurred in case of common drain pipes.

The outer and the inner diametres of TEMADRAIN are 7o and 6o mm respectively. The roll length is 15o m, its mass 53,7 kg, while its permeability exceeds by 2,5 that of traditional PVC drain pipe with 65 mm. TEMADRAIN can be laid using traditional machines or without opening a ditch.

3.4. Biological slope protection

Soil slopes can be protected against erosion damages covering special geotextiles on them. Geotextile type A 5 with 19o g/m is produced using natural fibrous material with 15% synthetic matter that slowly decomposes and glazes on the surface.
The textile typ 2oo - an exclusively synthetic fibrous material - can lastingly protect the slope against erosion damages, it decomposes only after a longer time period.
Both materials owing to their dark brown colour do not influence the aesthetics of landscape. Because of their porosity they can guarantee the water absorbing and water retention capacity of soils, besides they have weed preventive ability too.
The material in rolls can be laid on the prepared surface starting from the uppermost point of slope. The fastening takes place in a distance of 3 m using stakes or cuttings with sprouting ability. Small windows are cut in the textile where seedlings, root cuttings or branches with sprouting ability can be planted as it can be seen on Figure 3.

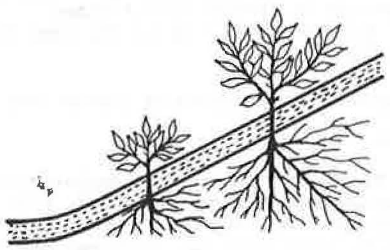

Figure 3. Biological slope protection with geotextile

The textile with grass seeds typeFÜTEX is used for the grassing of slope or other surface where grass seeds are placed in a textile coat with high cellulose content, the coat of 3oo g/m mass per unit area are reinforced with needle felting. The grass seed mixture can be selected as a function of actual needs.

The surface to be protected should be covered using 8-1o cm thick humus layer while the textile with grass seed is to be overlayed with another 1-2 cm thick humus layer. The plantation should be done in March-April or in August-September. In casė of watering possibility, it can be planted, however, - excepting for winter frost - any time because the textile protects against the non-desirable heat effects and the too rapid drying out. Figure 4. presents the condition after two months.

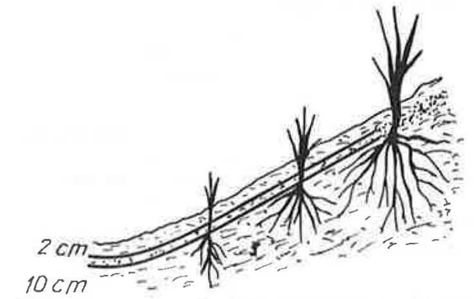

Figure 4. Textile with grass seed: 2 months after sowing

3.5.Textile container for plants

The container that decomposes in soil can be used for the raising, the transportation and the transplantation of plant multiplying material. The basic material of textile container - 85% natural fibre (mainly cellulose) and 15% synthetic material - causes no environmental damage because its decomposition takes place in a short time. Its mass of unit area amounts to 19o g/cm. Five different sizes are produced having volumes between o,6 and 3,6 litres. Figure 5. shows the smallest and the largest textile container.

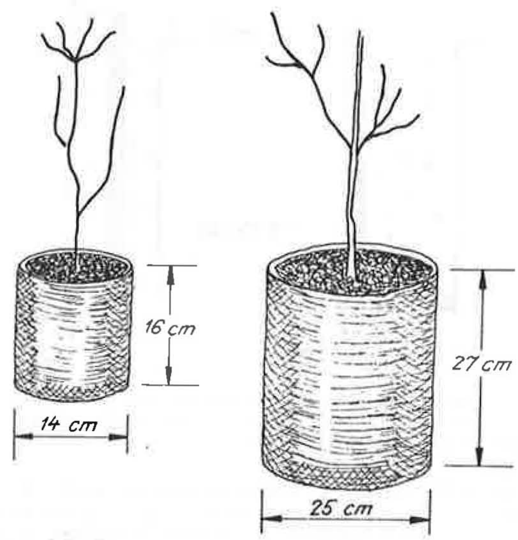

Figure 5. Smallest and largest textile container

(1) Gáspár L., "Dammgründung mit Geotextilien auf Böden mit geringer Tragfähigkeit" "Sixth Danube-European Conference on Soil Mechanics and Foundation Engineering, Section 1/a. Varna, 198o

(2) Question I. Earthworks - Drainage - Subgrade, Hungarian Report . XVIIth World Road Congress, Sydney 1983