SOME CONSIDERATIONS ABOUT THE PROPER SELECTION OF GEOSYNTHETICS FOR RAILWAY NETWORKS IN ROMANIA

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ABSTRACT

The Romanian railway network will be improved in order to ensure a higher velocity limit, up to 160km/h. The paper deals with the importance of the monitoring and testing activity regarding the short and long time behavior of the geosynthetic materials used for the railway subbase reinforcement.

The main types of tests on geosynthetic materials are being presented and an important case study is analyzed. Also a case study regarding the geogrid effect within the reinforced subbase of the railway network during modernization works is presented along with conclusions for the design activity.

Keywords: Railway, geosynthetics, design

INTRODUCTION

Less commonly found in the literature are comparisons between the results of measurements from actual works involving geosynthetic materials in operation and the results of numerical modeling, respectively.

Two other important aspects for both general analysis systems may be mentioned, namely:

- the necessity of knowing the mechanical and hydric parameters of geosynthetic materials' behavior in interaction with usually non-cohesive soils;
- verifying the strain–stress relation from the geosynthetic material–soil ensemble by measurements on small and/or natural scale models, and on exploited works.

In the following are some information which illustrate the importance of the above mentioned aspects within transport infrastructure works in Romania.

SOME CONSIDERATIONS ABOUT THE IMPORTANCE OF GEOSYNTHETICS TESTING IN ROMANIA

As it is known, the Romanian lithology is characterized by soils with a great deformability. According to these special conditions, the foundation ground improvement has become a very important problem together with the geotechnical stabilization structure. For a great efficiency, it is necessary to choose the proper geosynthetic material and after that to check its behavior inside different engineering works.

In order to establish the appropriate geosynthetic material for transportation infrastructure works, the following tests are usually performed in the geosynthetic laboratory and on site:

- wide–width tensile test (Fig. 1);
- tensile test for joints/seams by wide (width method);
- static puncture test (CBR test);
- dynamic perforation test (con drop test);
- thickness determination under specified pressures;
- determination of mass per unit area of geotextile products;
- determination of friction characteristics by using the direct shear apparatus (Fig. 2);
- determination of water permeability characteristics;
- site tests for peeling, shearing, and tensile strength of geomembranes and geotextiles;
- study on the geotextiles' permeability for unavailable soils conditions and under variable hydraulic gradient (Fig. 3).

All tests mentioned above are very useful for the design results' improvement together with the field measurement of the infrastructure works.

Fig. 1 Apparatus for tensile strength and elongation at break testing

Fig. 2 Direct shear apparatus

Fig. 3 Apparatus for permeability and clogging capacity testing

THE GEOSYNTHETICS BEHAVIOR CORRESPONDING TO THE ROMANIAN RAILWAY NETWORK

It is about the Trans-European corridors that run across Romania in order to ensure the links between Romania and other European countries.

The Romanian modernization project has the following objectives:

- higher traffic comfort;
- velocities up to 160 km/h;
- higher loads on the track axle, up to 225kN.

In order to fulfill these requirements it is necessary to improve the bearing capacity of the railway subgrade.

According to the Romanian Standards (NTF 72 – 04 and NP 109-04), some new recommendations concerning the railway track foundation improvement with geosynthetic materials are being mentioned.

The new recommendations are based mainly on the Romanian case studies analysis, as well as on other countries' experience.

Very important in the geosynthetic selection activity is the monitoring of long time behavior for a studied railway embankment. In Fig. 4, the general terminology is presented.

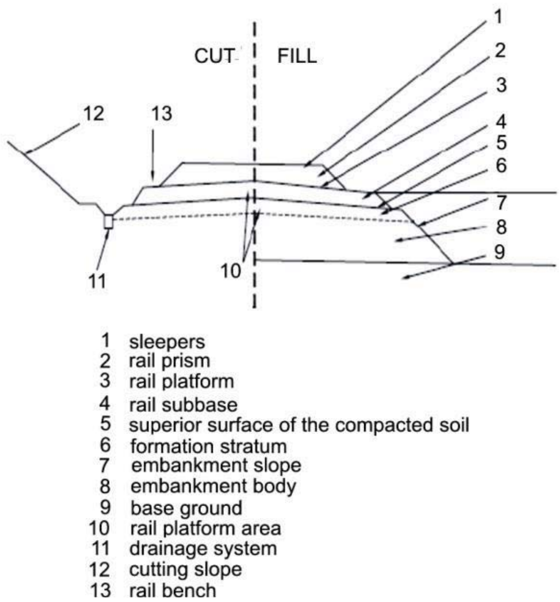

Fig. 4 Railway embankment structure (Chirică et al. 2008)

In order to analyze the embankment behavior, it is necessary to know the foundation ground lithology.

In the analyzed case, the lithology consists of:

- clayey silt;
- yellow loessial soil with the water table level in the base;
- silty clay.

For analyzing the embankment behavior, settlement variation diagrams were analyzed for four years on a 14km long railway. From the diagram shown in Fig. 5 (length scale of 1:40000), the influence of rail traffic on settlements is clearly seen on the railway line in time. Settlements have increased by 10mm. As a result, both the geogrid used as reinforcement and the geotextile layer used against capillarity have suffered significant deformations in time (Fig. 6). The geosynthetic material samples taken were subjected to physical-mechanical testing. The analysis results led to important conclusions about the process of selecting the geosynthetic materials for railways.

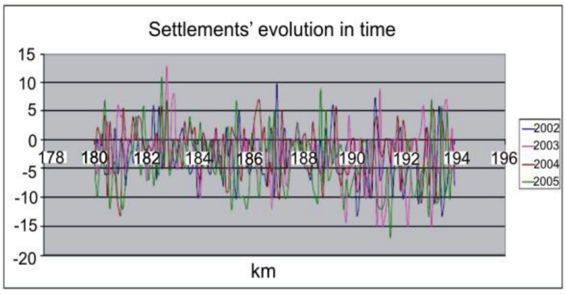

Fig. 5 Settlement variation diagram (Ţenea 2007)

Fig. 6 Geosynthetic sample extracted from the studied railway embankment (Ţenea 2007)

The thickness of the subbase of the railway is established with the static deformation modulus at reloading, E_{v2}, which represents the dependence between the static load of a loading plate and the value of settlements during the test.

The static deformation modulus at reloading is determined during the geotechnical verification of the rail platform. The minimum values requested for the upper surface of the embankment and the base course are presented in Table 1. The E_{pl} values (the deformation modulus at base course level) are set for a maximum load per axle of 22.5kN (Fig. 7).

For designing the thickness of the railway subbase it is necessary to know the static deformation modulus at reloading for the upper surface layer of the embankment in the most unfavorable weather conditions (during spring and thawing), especially if the embankment consists of cohesive soils sensitive to climatic conditions.

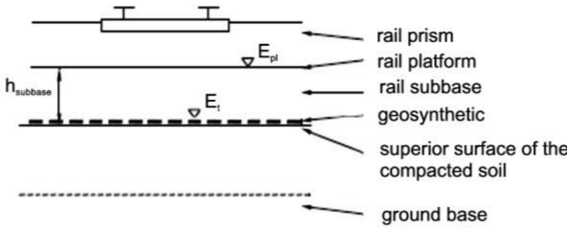

Fig. 7 Rail subbase thickness determination (Chirică et al. 2008)

Table 1 Minimum values for E_{v2}

Line type			RP*	SSCS** [MN/m²]
New rail	Current line for European corridors and main rails		120	80
	Current line for secondary lines		100	60
	Other lines		80	45
Mainte-nance	Existing lines	v<160km/h	80	45
		v≤160km/h	50	20

*rail platform
**superior surface of the compacted soil

In order to find out by calculus the rail infrastructure's bearing capacity, the deformation modulus of the upper face of the embankment will be modified by a correction coefficient "y", which reflects the humidity influence.

The reduced deformation modulus (E_{tr}) for the upper face of the embankment is determined with the equation:

$$E_{tr} = E_t \cdot y \tag{1}$$

where:

E_{tr} = the reduced deformation modulus for the upper face of the embankment in MPa

E_t = the deformation modulus measured in MPa
"y" = the correction coefficient related to the consistency index of soil, Ic.

The correction coefficient "y" values for gravel and sand, and for cohesive soils respectively are given in Tables 2 and 3.

Table 2 The "y" correction coefficient values for non-cohesive soils

Soil type	"y" correction coefficient value
Sands with particle under 0.06mm<5% Gravels with particle size under 0.06mm<35%	1.0
Sands with particles under 0.06mm between 5 and 35%	0.9

Table 3 The "y" correction coefficient values for cohesive soils

Soil type	Consistency index at E_t determination		
	I_c<0.5	0.5<I_c<1.0	I_c>1
	"y" correction coefficient value		
Silt and clay with gravel<35%	1.0	0.9	0.8
Silt and clay with sand<35%	1.0	0.8	0.6
Silt and clay with low plasticity index w_L<35%	1.0	0.7	0.5
Silt and clay with medium plasticity index 35%≤w_L≤50%	1.0	0.6	0.4
Silt and clay with high plasticity index w_L>50%	1.0	0.5	0.3

For the railway's existing embankments that need to be rehabilitated or modernized, there are necessary some foundation works including reinforcements such as geogrids.

The minimum required thickness for the drain materials beneath the foot of the sleeper is determined depending on the deformation modulus at the subbase (E_{pl}) and on the reduced deformation modulus at the upper face of the embankment (E_{tr}).

If the deformation modulus corresponding to the superior surface of the foundation ground is E_t <10MN/m^2, some measures to improve the mechanical properties of the subbase layer should be considered, such as:

• partial or total removal of formation strata;
• mechanical or chemical stabilization;
• reinforcing with geosynthetics.

The required thickness of the subbase with and without reinforcement is determined according to the diagram presented in Fig. 8. The determined thickness is rounded up to an integer multiple of 5 cm.

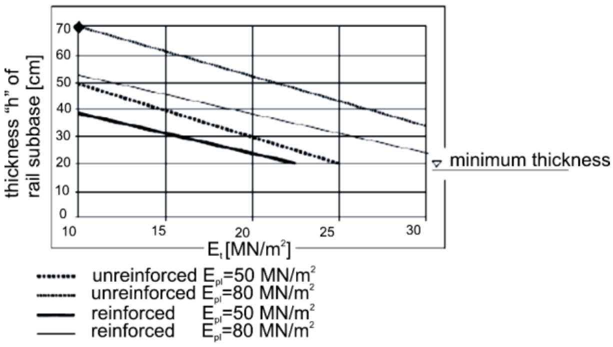

Fig. 8 Determination of thickness subbase diagram (Chirică et al. 2008)

CONCLUSIONS

In order to realize a proper Romanian railway network, the following main activities are required:

- geotechnical field studies and monitoring activity results analysis;
- an adequate selecting methodology applied for the geosynthetic materials used in the railway embankments structures as reinforcement; the dynamic impact should be considered;
- the efficient and optimal design of the railway subbase thickness in order to assure minimum values for the settlements corresponding to the railway infrastructure under rail-traffic loads.

REFERENCES

Chirică A., Barariu A., Taloş L. and Baicu A. (2008). Interplay between practice and laboratory testing of geosynthetics. Proc. 4th International Conference of Geosynthetics, Edinburgh, United Kingdom.

NP 109-04. (2004). Normativ privind proiectarea liniilor şi staţiilor de cale ferată pentru viteze până la 200 km/h. Normative for Designing of Rails and Stations for Railways for Speed up to 200 km/h.

NTF 72-04. (2004). Infrastructura feroviară. Terasamente de cale ferată. Prescripţii tehnice metodologice pentru controlul calităţii execuţiei la linii noi. Railway Infrastructure Normative. Railway Bed. Technical prescriptions and Methods for Quality Control Executions at New Rails.

Ţenea D. (2007). Contribuţii asupra metodelor de tratare şi ranforsare a pământurilor cu structură metastabilă în cazul căilor de comunicaţie. Teză de doctorat, UTCB. Contributions on Treatment and Reinforcement Methods of Soils with Metastable Structure for Communication Ways. PhD Thesis, TUCEB.