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# The use of spunbonded geotextile in railway track renewal St. Petersburg-Moscow

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ABSTRACT: A research project was performed in order to improve and renew an existing railway line to handle higher speed trains. Old contaminated ballast layer has been removed, cleaned and re-installed after laying a thermally bonded geotextile with high initial modulus as separation and stabilisation layer. The operation has been made with specialised equipment without removing the track. After one and after five years the track has been opened and the performance and behavior of the geotextile has been analysed. The research showed that the proposed solution proved sufficient reliability of the design and of the selected geotextile.

## 1. INTRODUCTION

The railroad St. Petersburg-Moscow (Russia) founded 150 years ago with a length of 650 km was being renewed to handle higher speed trains. After reconstruction, the line was used for passenger transportation as well as freight cargos with axle load up to 230 kN/axle.

These load conditions demanded serious improvement of the track substructure. During the track's lifetime a mass of old ballast material with a thickness of up to 1,5m under the sleeper had accumulated. The old ballast consists mainly of crushed stone of 25-60 mm and contains up to 40 % of small particles, 5-6 % of which are under 0,1mm. Due to dynamic loads these small particles penetrated into the ballast layer and caused insufficient strength of the ballast. This pumping effect occurred mostly in spring and after heavy rains.

Therefore one of the objectives of the track renewal was reinforcement of roadbed and ballast section to provide long-term stability of the track.

## 2. TRACK RENEWAL OPERATION

For reaching the required track stability it was decided to clean the old ballast to a depth of 0.4 - 0.45 m under the sleepers over the whole line and to install a separation layer between cleaned ballast and old ballast. In total around 800 km of geotextile was installed.

### *2.1. Installation*

The line renewal operations were done during 8 hours daily. After that, the line was opened again for traffic. Crushed stone cleaning and geotextile laying were performed using specialised equipment without removing the track. The geotextile was laid on the top of the old ballast and covered with cleaned crushed stone without additional protective layer.

In order to drain the water, the edge of the old removed ballast was cut in a way that it formed an incline of 4%.

Figure 1. Principle of installation of the geotextile and new ballast layer

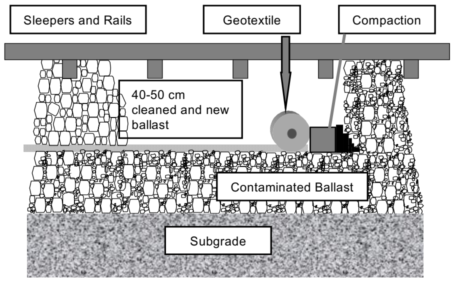


Figure 2. Track renewal with specialised equipment

*2.2. Product selection*

A thermally spunbonded nonwoven geotextile of 100% polypropylene with high initial modulus and high energy absorption resistance was selected. The pre-compressed structure with minimal thickness allowed a maximum coil length with fixed roll diameter.

Table 1. Typar® 3857 Main properties

| | Standard | Unit measure | |
|---|---|---|---|
| Breaking load | EN ISO 10319 | kN/m | 20.5 |
| Elongation at rupture | EN ISO 10319 | % | 70 |
| Load at 5% elongation | EN ISO 10319 | kN/m | 9.8 |
| Energy absorption | EN ISO 10319 | kJ/m$^2$ | 10 |
| CBR puncture | EN 12236 | N | 3130 |
| Permeability coefficient at 20 kN/m$^2$ | SN 640550 | $10^{-4}$ m/s | 2.7 |
| Surface density | EN 965 | g/m$^2$ | 290 |
| Thickness under the load of 2 kN/m$^2$ | EN 964-1 | mm | 0.75 |
| Coil length | | m | 110 |

## 3. EVALUATION OF PERFORMANCE

*3.1. Pilot site build-up*

As the concern was raised that without additional protective sand layer damage could occur on the geotextile, a pilot site was constructed on the line St. Petersburg - Moscow. Geotextiles were installed according to six different build-ups.

1. Cleaned crushed stone – 1 layer of selected geotextile – old ballast.
2. Cleaned crushed stone – protective layer of sandy gravel - 1 layer of selected geotextile – old ballast.
3. Cleaned crushed stone – protective sand layer – 1 layer of selected geotextile – old ballast.
4. Cleaned crushed stone – 1 layer of selected geotextile – protective sand layer – old ballast.
5. Cleaned crushed stone – 2 layers of selected geotextile – old ballast.
6. Cleaned crushed stone – 1 layer of needlepunched geotextile 400g/m² – old ballast.

After one year of operation a sample of the geotextile was excavated on the site and the ballast was examined for contamination. Geotextile samples were tested in a laboratory and changes in its area weight, moisture content and damage resistance were analysed.

*3.2. Discussion of results*

The additional sand layer improved the geotextile performance. A sand layer below the geotextile provided the additional advantage of a plane surface for the installation. It was noticed that the geotextile was under tension, which shows a possible stabilisation effect of the geotextile.
The first test took place after one year of operation and the second in 2001 after five years of service.
Only some minor puncture holes of 1-2 mm were found, which represented only 0.2 % of the total surface area of the geotextile. The lowest result on moisture and soil content in the structure was found with additional sand layers. Without additional sand layer a much higher content has been found for the thicker needlepunched product compared to the selected thermal bonded product.

Table 2. Geotextile parameter after one year of use in the railway track

| № | | | Area weight, g/m$^2$ | | | | Moisture content, |
|---|---|---|---|---|---|---|---|
| | | | new | wet | dry | Soil content | % |
| 1 | Geotextile only | | 290 | 828 | 641 | 351 | 29.1 |
| 2 | Geotextile under sandy gravel layer | | 290 | 541 | 442 | 152 | 22.4 |
| 3 | Geotextile under sand layer | | 290 | 486 | 443 | 153 | 9.6 |
| 4 | Geotextile above sand layer | | 290 | 581 | 511 | 221 | 13.7 |
| 5 | Geotextile 2 layer | Upper layer | 290 | 763 | 600 | 310 | 27.2 |
| | | Lower layer | 290 | 780 | 632 | 342 | 23.4 |
| 6 | Needle-punched, 1 layer only | | 400 | 1468 | 1035 | 635 | 41.9 |

## 4. EXCAVATION AFTER 5 YEARS

After 5 years of service life the track was opened on several sections in order to determine the performance of the geotextile. Samples were excavated and tested to determine area weight, breaking load and water permeability.

Figure 3. Excavation from under the track

Figure 4. Excavated sample of geotextile with some old ballast

### 4.1. *Retained mechanical properties*

After 5 years of service life the total damage surface was 0.3 % compared to 0.2 % after one year. The retained strength after one year was 74 % and after 5 years still 72 % with a remaining elongation of up to 30%.
The decrease in material strength as well as most of the damages occurred in the beginning and did not further change with time. Initial modulus did not change.
Figures 5 and 6 show the stress-strain curves of the geotextile after 5 years at different locations compared to the initial results. The tensile strength test was performed on 5cm wide samples. The geotextile showed no decrease in puncture strength. Puncture strength after 5 years of service life was 1281 N compared to 1280 N of initial strength.

Figure 5. Typar® 3857 stress-strain-curve (MD)

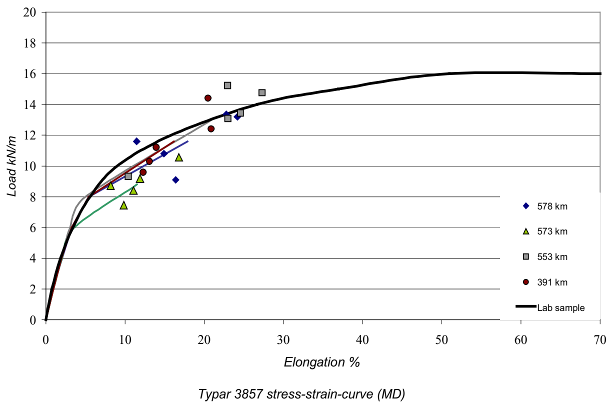


Figure 6. Typar® 3857 stress-strain curve (XD)

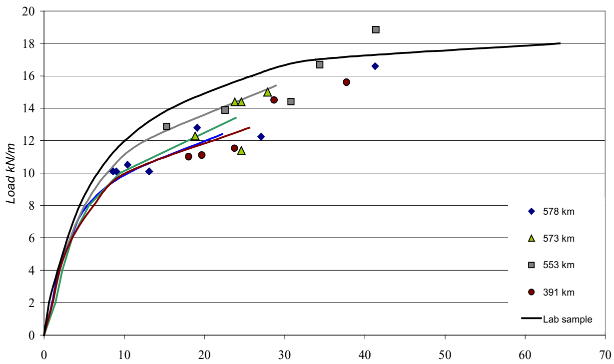


Table 3. Tensile strength and elongation after 5 years [N/5cm]

| km | Sample | Pmax, H | Elong. max, % | Pmax, H | Elong. max, % |
|---|---|---|---|---|---|
| **578 km** | 1 | 540 | 14.9 | 505 | 13.1 |
| | 2 | 580 | 11.6 | 526 | 10.4 |
| | 3 | 660 | 24.1 | 612 | 27.1 |
| | 4 | 455 | 16.0 | 640 | 19.1 |
| | 5 | 668 | 22.9 | 830 | 41.3 |
| | Mean | **581** | **17.9** | **623** | **22.2** |
| | *STDEV* | *89* | *5.4* | *129* | *12.5* |
| **573 km** | 1 | 420 | 11.1 | 614 | 18.9 |
| | 2 | 373 | 9.8 | 570 | 24.6 |
| | 3 | 436 | 8.2 | 750 | 27.9 |
| | 4 | 459 | 11.7 | 720 | 23.8 |
| | 5 | 528 | 16.7 | 720 | 24.6 |
| | Mean | **443** | **11.5** | **675** | **23.9** |
| | *STDEV* | *57* | *3.2* | *78* | *3.2* |
| **553 km** | 1 | 654 | 23.0 | 694 | 22.6 |
| | 2 | 761 | 22.6 | 942 | 41.4 |
| | 3 | 466 | 10.4 | 720 | 30.8 |
| | 4 | 672 | 24.6 | 643 | 15.3 |
| | 5 | 738 | 27.3 | 834 | 34.4 |
| | Mean | **658** | **21.6** | **767** | **28.9** |
| | *STDEV* | *116* | *6.5* | *120* | *10.2* |
| **391 km** | 1 | 720 | 20.5 | 550 | 18.0 |
| | 2 | 560 | 13.9 | 576 | 23.8 |
| | 3 | 479 | 12.3 | 555 | 19.7 |
| | 4 | 620 | 20.9 | 780 | 37.7 |
| | 5 | 515 | 13.1 | 725 | 28.5 |
| | Mean | **579** | **16.2** | **637** | **25.6** |
| | *STDEV* | *95* | *4.2* | *107* | *7.9* |

### 4.2. *Retained hydraulic properties*

Some contamination of the geotextiles was noticed after extraction.Tests of the un-cleaned geotextile with ballast showed that the water permeability of the whole structure decreased only 1.5 times. The conditions found on the track at various sections confirmed that the existing decrease in water permeability of the geotextile did not affect humidity conditions of the structure as most part of incoming water is drained in the ballast layer on top of the geotextile. During extraction it was found that the moisture content of the ballast under the geotextile was 1-2% less than above the geotextile.
It was clearly visible that the contamination was mainly coming from the top of the structure due to abrasion of ballast and rain falls. Only minor contamination was found on the bottom part of the geotextile.

## 5. STABILISING EFFECT

During extraction it was found that the geotextile was stretched which shows that it functioned also as a stabilisation layer.
In order to evaluate this stabilising effect of the geotextile, load cells were installed under the geotextile layer below the track axis, below the sleeper butt, on rail axis between sleepers and on rail axis under sleeper. In Russia similar measurements were repeatedly made in the ballast without geotextile. Based on these measurements in the depth of 0.4 - 0.5 m under the sleeper it was found that regardless of rolling stock unit and sleeper type, stress reduction factor on sleeper axis amounts to Ko/p= 0.33 and stress reduction factor on sleeper butt amounts to Km/p= 0.61. Analysing data from table 3 in comparison with coefficients for standard construction without geotextile one can conclude that

for all rolling stock units load balancing has occurred that demonstrates the stabilising effect of the used geotextile. Surface load balancing was the largest in case of passenger trains with lowest axle load and highest speed.

Table 4. Stress reduction factors on the ground under geotextile in cross-section.

| Rolling stock unit | Axle load, kN/axle | Speed, km/h | Stress reduction factors | | |
|---|---|---|---|---|---|
| | | | on track axis | on sleeper butt | on tie space |
| Freight locomotive | 245 | 70 | 0.53 | 0.78 | 0.82 |
| Freight car | 230 | 70 | 0.52 | 0.76 | 0.83 |
| Passenger locomotive | 191 | 110 | 0.67 | 0.84 | 0.90 |
| | | 160 | 0.63 | 0.85 | 1.00 |
| Passenger car | 157 | 110 | 0.79 | 0.86 | 0.97 |
| | | 160 | 0.67 | 0.69 | 0.83 |
| High-speed electric train | 167 | 175 | 0.68 | 0.75 | 0.92 |

## 6. CONCLUSIONS

The tests confirmed that the proposed solution proved sufficient reliability of the design with the selected geotextile in the ballast without protective layers.

- Minor damage that had no influence on track functionality was found on the geotextile
- Geotextile works as a separating layer and prevents contamination of the new ballast
- Contamination of the geotextile had little influence on the drainage capacity of the whole system
- Contamination and damage occurs in the beginning; it becomes stable with time
- The selected geotexile with high initial modulus stabilised the whole structure

Track measurement cars are passing twice a month. According to these measurements, track sections stabilised with the selected geotextile remain flat after several years and ensure train operation on required speed and axle loads.

## 6. REFERENCES


Central Scientific & Research Institute of Ministry of Rails of Russian Federation, 1972. Stress and elastic deformations in the ballast bed under trains impact. Moscow: Publishing house "Transport".

Diederich, R. 2000. Evaluation of Installation Damage of Geotextiles. A Correlation to Index Tests, YiChang China 2000, Fifth Conference on Geosynthetics

Rails and Engineering Department, Ministry of Rails of Russian Federation, 1999.Technical guideline for the application of foamed polystyrene and geotextile in railway ballast bed without removal of rails and sleepers. Moscow.

Research report N 84/97, 1997. Laboratory evaluation of Russian geotextiles for the possible application as separation layer in the railway St. Petersburg-Moscow. Moscow: University Of Transport Engineers.

Research report N 06/97-z, 1998. Observations on the rails stability, conditions of ballast bed and protection layers on the test repair department. Moscow: Research & Production Company "Geonika-PM".

Research report N 03/98-z, 1998. Observations on the rails stability, conditions of ballast bed and protection layers on the test repair department. Moscow: Research & Production Company "Geonika-PM".

Research report N 68/99, 1999. Measurements of stress and deformations in the ballast bed on the high speed test section on a stable sub-base. Moscow: University Of Transport Engineers.

Watn, Eiksund, Knutson. 1998. Deformations and Damage of Nonwoven Geotextiles in Road Construction, Atlanta 1998, Sixth International Conference on Geosynthetics