GEOSYNTHETICS IN RAILWAYS ENGINEERING: WORKING TOWARDS 2025

GEOSYNTHETICS USES FOR HIGH SPEED LINES AND TRADITIONAL RAILWAYS IN FRANCE

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French national railways

Agenda

- French national rail network: high speed and traditional lines.
- Geosynthetics used in railways structures:
  - within the bearing structure of the rail
  - subgrade improvement

photos from H Giraud SNCF
French national rail network 2018

1823: first fret line 23 km
1829: first line with passengers 56 km

high speed lines since 1981
V>220 km/h = 2000 km
other lines: 29 000 km

from H Giraud SNCF
Projects on the national network

1 600 projects scheduled: new lines, tracks renewal, switches, signalling, stations, level crossing,,,

renewal of railway lines: 1000 km/year
Geosynthetics consumption in high speed lines

LN1 LGV Sud Est Paris-Lyon -1981
LN2 LGV Atlantique Paris-Tours/Le Mans -1989
LN3 LGV Nord Paris-Lille - 1993
LN4 LGV Rhone Alpes – Contournement de Lyon -1994
LN5 LGV Méditerranée Lyon-Marseille- 2001
LN6 LGV Est phase 1 Paris-Metz-Nancy- 2007
LN7, LN8,...

from H Giraud, A Robinet - Geosynthetics in railway-
10eme Rencontres Géosynthétiques Mars 2015 , La Rochelle
Why Geosynthetics are be used:
Geosynthetics in railways

against pollution of the ballast (separation/filtration)  drainage of the platform

bearing capacity

photos from H Giraud SNCF
Geosynthetics are used close to the rail structure for:

- separation / filtration to improve the stability of the platform
- longitudinal drainage system
- waterproofing

But also:

- Basal reinforcement of embankment
  - soft soil,
  - piled embankment
  - void spanning
- Temporary reinforced steep slope
- Drainage of the embankment
Geosynthetics at different levels

Geosynthetics in railways

- under the ballast
- subbase / blanket layer
- drainage
- basal reinforcement:
  (soft soil, piled embankment, cavities…)

![Diagram](image-url)
Sub-rail structures in high speed and conventional lines

Geosynthetics in railways

Sub-rail structures in high speed lines

Sub-rail structures in conventional lines

thickness of the subgrade depends on the initial bearing capacity (S0 to S3)

<table>
<thead>
<tr>
<th>S0: $EV_2 &lt; 30\text{MPa}$</th>
<th>poor soil - not suitable</th>
</tr>
</thead>
<tbody>
<tr>
<td>S1: $30\text{MPa} \leq EV_2 &lt; 50\text{MPa}$</td>
<td>acceptable</td>
</tr>
<tr>
<td>S2: $50\text{MPa} \leq EV_2 &lt; 80\text{MPa}$</td>
<td>good</td>
</tr>
<tr>
<td>S3: $EV_2 \geq 80\text{MPa}$</td>
<td>very good</td>
</tr>
</tbody>
</table>

For high speed lines:
- soil improvement needed
- sub-layer + subgrade
- sub-layer only

For conventional lines:
- soil improvement needed
- thick sub-layer
- thin sub layer
- sub-layer only

separation geotextile is used at the base between the ground and the sub-layer
### SNCF specifications for separation/filtration – IN 0261

*Geotextile between blanket layer and subgrade*

<table>
<thead>
<tr>
<th>Property</th>
<th>Standard/ISO Number</th>
<th>Unit</th>
<th>Requirement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Weight (MS)</td>
<td>EN ISO 10319</td>
<td>g/m²</td>
<td>385 / 415</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>260 / 300</td>
</tr>
<tr>
<td>Tensile strength</td>
<td>EN ISO 10319</td>
<td>(kN/m)</td>
<td>24</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>20</td>
</tr>
<tr>
<td>Elongation</td>
<td>EN ISO 10319</td>
<td>%</td>
<td>≥ 50%</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>≥ 50%</td>
</tr>
<tr>
<td>Puncture resistance (pyramidal)</td>
<td>NF G38019</td>
<td>kN</td>
<td>≥ 1,2</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>≥ 1,0</td>
</tr>
<tr>
<td>Dynamic perforation (cone drop)</td>
<td>EN ISO13433</td>
<td>mm</td>
<td>&lt; 15</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>&lt; 18</td>
</tr>
<tr>
<td>Permeability normal to the plane</td>
<td>EN ISO 11058</td>
<td>m/s</td>
<td>0,05 m/s</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>0,03 m/s</td>
</tr>
<tr>
<td>Characteristic Opening Size</td>
<td>EN ISO 12956</td>
<td>µm</td>
<td>≥ 63 µm</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>≤ 100 µm</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>≥ 63 µm</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>≤ 100 µm</td>
</tr>
<tr>
<td>Water flow capacity under 100 kPa</td>
<td>EN ISO 12958</td>
<td>m²/s</td>
<td>5.10⁻⁷</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>≥ 2.10⁻⁷</td>
</tr>
</tbody>
</table>

**A1**  depth < 1m, used when gsx submitted to dynamic effect

**A2s** depth > 1m
Geotextile between blanket layer and ballast

Geotextiles in railways

- A geotextile resistant to abrasion (following specification from JP Raymond)
  - avoid a work in depth for the refurbishment of the structure (just levelling of the layer below the ballast)
  - can survive and work more than 25 years under a traffic of 100,000 Tons/day
  - allows a reduced maintenance

A sleeper of a railway track is subjected to 20 tonnes load at a frequency of 50Hz with the use of eccentric wheels.
10 hours under the vibrogir corresponds to a yearly traffic of 100,000 tonnes per day.
200 hours represents 20 years of traffic
Case studies -
Geotextile between blanket layer and ballast

Saint Pierre de Moutier
France 2007
Differential settlements observed along the line inducing abnormal rail deflection

Sedan station France 2009:
AR20 used as an alternative to the placement of a thick blanket layer
Geosynthetics to improve bearing capacity

Geosynthetics between subgrade/ subsoil and blanket layer

- geosynthetic reinforcement to improve the bearing capacity is not commonly used
- experiments with geogrids and geocomposites have been done by SNCF, no definitive conclusion
- studies still going on

But a need for the rail network modernisation

2008 LGV Bourg-En-Bresse / Bellegarde (01) –Geocomposite PET 55/50 kN/m

Structure from top to bottom:

- Ballast
- Gravel 0/31.5 35 cm
- Geocomposite NW+PET 55/50 kN/m

Subgrade bearing capacity

50 Mpa ≤ Ev2 ≤ 70 MPa

Goal

100% optimum Proctor density

18 April 2018 at York Railway Museum
Basal reinforcement with geosynthetic in railways

1500 km of high speed railway line Paris/Bratislava/Budapest

Source: http://www.vigilancetgv.eu
Subsidence occurred during earthworks - HSL East 2010

Basal reinforcement with geosynthetic in railways – spanning voids

- **Void diameter**: 3m
- **Geosynthetic reinforcement**
  - **Surface settlement**: <1cm after 1 year
  - **Height**: 4m < H < 10m

- **Materials**:
  - Gravel 0/31.5
  - GTX PET 800 kN/m
  - Gravel 0/150mm
Very low bearing capacity near a bridge - HSL East 2010
Basal reinforcement with geosynthetic in railways - Embankment on piles

→ Expected settlement without soil reinforcement between 60 to 90 cm
**Embankment on piles**

Basal reinforcement with geosynthetics

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maximum height of the embankment</td>
<td>H = 16,5m</td>
</tr>
<tr>
<td>Spacing between piles</td>
<td>s = 2m x 2m</td>
</tr>
<tr>
<td>Piles diameter</td>
<td>D = 600 mm</td>
</tr>
</tbody>
</table>

**Surcharge = 30 kPa**

**Earthworks:**
- gravel 0/150mm
- gravel 0/40 mm
- Geosynthetic PET 1000 kN/m
- gravel 0/150mm
Conclusion

- Geosynthetics and drainage composites are a great help in railways jobs for:
  - respect of timeline,
  - saving of granular material,
  - small space for earthworks,
  - new environmental constrains
  - ...
- Uses of geosynthetics increased with new lines development
- Geosynthetic installation under ballast shall be optimised to respect the program of 1000 km/year lines renewal
- Better knowledge on the use of geosynthetics for reinforcement (bearing capacity) is needed