

Geosynthetics in railway constructions – groundwater protection

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ABSTRACT: Geosynthetics are used in railway construction predominantly in the field of earthworks. Thus, in Germany they are subject to the technical guideline “Ril 836 - Planning, constructing and maintaining earthwork constructions and other geotechnical structures” of Deutsche Bahn AG (German Railways). In addition to Ril 836 there is a new guideline “Technical requirements for geosynthetics in railway constructions (DBS 918 039) published in November 2015. Within this new DBS 918 039 several geosynthetic applications and the corresponding technical requirements are defined. Besides the conventional applications, like filtration and separation (geotextiles) or reinforcement (geogrids), there are also new applications like groundwater protection where geosynthetics are used. In application no. 3.11 (DBS 918 039) the geosynthetic clay liners (GCL) are regulated as sealing elements for groundwater protection and in application no. 3.12 (DBS 918 039) the geomembranes are defined as sealing elements. The geosynthetic clay liners and the geomembranes, respectively, work as a sealing underneath the railway track to protect groundwater e. g. in water protection areas.

Keywords: Railway, technical guideline, geomembrane, clay liner, sealing, water protection

1 DESIGN AND DEVELOPMENT OF GEOSYNTHETICS IN RAILWAY CONSTRUCTION

Geosynthetics are mainly used in railway construction for tasks in earthworks and civil engineering and are thus regulated in the guideline 836 “Planning, constructing and maintaining earthwork constructions and other geotechnical structures” (Ril 836) of Deutsche Bahn AG (German Railways). The development of geosynthetics started around 1960 with the processing of synthetic fibres into durable filter wovens with a high tensile strength. By this, a quick reduction in the use of traditional construction elements, especially high-quality mineral mixtures, could be achieved. Due to further developments in the manufacturing technology, e. g. the processing of nonwovens, wovens and mineral components to geocomposites, the use of classical building materials e. g. clay sealings can meanwhile nearly completely be given up. In addition to important ecologic and economic advantages, new applications as well as designs and construction methods have been increasingly developed in the field of railway construction since then. Within the range of competence of Deutsche Bahn (German Railways), geosynthetics were used for the first time in 1973.

2 INTRODUCTION OF THE DBS 918 039 (STANDARD OF DEUTSCHE BAHN AG)

As of November 10, 2015 the DB AG (German Railways) issued the Technical Note (TM) 4-2015-10838 I.NPF 2 in order to introduce the DB Standard (DBS) 918 039. This standard regulates the technical terms of delivery for geosynthetics in railway constructions of Deutsche Bahn. Within the scope of Ril 836 the geosynthetics provided for the described applications may only be installed if a corresponding manufacturer-related product qualification (HPQ) of Deutsche Bahn AG is available for the respective product.

2.1 Overview of the applications according to DBS 918 039

- Application 3.3:** Filter element in the drainage system of the railway construction
 The filter nonwoven serves as separation layer between the pipe bedding and the in-situ subsoil. It encases the gravel pack around the water collector, so that no fine particles are washed in from the surrounding soil and clog the collector over time.
- Application 3.4:** Filter and separation element under base courses
 The filter nonwoven separates soil layers of different grain sizes (formation protection layer and in-situ soil) and prevents the washing out of fine particles by the soil retention capacity.
- Application 3.5:** Reinforcing element with additional separation and filtration effect (without design approach)
 The geosynthetic serves in analogy to application 3.4 as separation and filter element and improves at the same time the bearing capacity of the formation protection layer on a foundation with a low bearing capacity.
- Application 3.6:** Reinforcing element in base courses (without design approach)
 The geogrid reinforcement of the base course improves the bearing capacity on weak subsoils. Where applicable, the necessary base course thickness to achieve the required bearing capacity can be reduced.
- Application 3.7, 3.8 and 3.9**
- Application 3.7:** Isotropic reinforcing element in earthworks (with design approach)
- Application 3.8:** Anisotropic reinforcing element in earthworks (with design approach)
- Application 3.9:** Extremely anisotropic reinforcing element in earthworks (with design approach)
 The geogrids act as reinforcing element to increase the stability in embankments, steep slopes and retaining structures as well as for the construction of load distribution platforms within the framework of track deep foundations as geosynthetic-reinforced ground pad.
- Application 3.10:** Drainage element with a high resistance to alkalis used for the drainage of backfill areas.
 The geosynthetic drainage system is used for the drainage at the bridge abutment by collecting the draining water as well as for the effective and safe discharge of the collected water.
- Application 3.11:** Sealing element in earthworks (geosynthetic clay liner)
 The geosynthetic clay liners serve as barrier under the track to protect the groundwater e. g. in water protection zones.
- Application 3.12:** Sealing element in earthworks (geomembrane)
 The geomembranes serve as sealing system beneath the track in order to protect the groundwater e. g. in water protection zones.
- Application 3.13:** Protection element for geosynthetic clay liners and geomembranes in earthworks
 The nonwoven serves as protection element against mechanical damage for the sealing system concerned.
- Application 3.14:** Nonwovens for the improvement of the track formation for use in the existing network (installation directly under ballast)
 The nonwoven serves as track formation improvement alternatively to the installation of a formation protection layer under defined operational and geotechnical parameters.

3 REGULATIONS FOR GROUNDWATER PROTECTION

3.1 Guideline 836

Within the scope of responsibility of Deutsche Bahn, the planning and structural requirements for earthworks are defined in the guideline (Ril) 836 "Planning, constructing and maintaining earthwork constructions and other geotechnical structures".

The protection of waters and soils from harmful substances resulting from regular rail traffic or from accidents is regulated in the module 836.0509 "Water and Soil Protection" dated December 20, 1999. Currently this module is being revised and is expected to replace the previous module 836.0509 as module 836.4107 "Structural Engineering in Water Protection Areas" in 2018. The new module will - as to its content - be based on the revised guideline in road construction, the so called RiStWag 16 "Richtlinien für bautechnische Maßnahmen an Straßen in Wasserschutzgebieten" (Guidelines for constructional measures

on roads in water protection areas). The constructional design of the sealing measures according to module 836.0509 provides, in principle, the use of geosynthetic clay liners (GCLs) and geomembranes (GMs).

3.2 DB Standard 918 039

The applications described in the DBS 918 039 include amongst others also the use of geosynthetics for groundwater protection measures. For use as sealing element in earthworks the installation of geosynthetic clay liners is regulated in application 3.11 and the installation of geomembranes in application 3.12. The geosynthetic clay liners and the geomembranes, respectively, serve as sealing element under the track for groundwater protection e. g. in groundwater protection areas.

3.2.1 Application 3.11: Geosynthetic Clay Liners (GCLs)

In application 3.11 the product requirements for a „sealing element in earthworks (geosynthetic clay liner)“ are defined. Geosynthetic clay liners are factory-made hydraulic barriers made of high-swellable bentonite and geosynthetics forming a shear strength transmitting composite. Two durable geotextile components encapsulate the intermediate homogeneous layer of bentonite powder in the long term and safe from erosion. In contact with fresh water the bentonite swells rapidly and thus creates a homogeneous, gel-like sealing layer.

Amongst others the following product requirements are exemplarily defined for the complete product:

Peel strength MD and CMD ≥ 7 kN/m

Water permeability perpendicular to the plane $k_v \leq 5 \times 10^{-11}$ m/s

Maximum tensile strength in MD and CMD ≥ 10 kN/m

For the mineral sealing layer i. a. the following product requirements are defined:

Mass per unit area for water content 0%

Sodium bentonite $\geq 4,000$ g/m²

Calcium bentonite $\geq 8,000$ g/m²

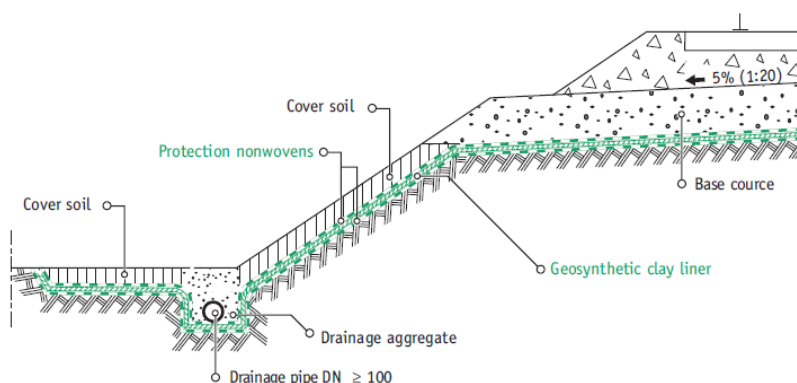


Figure 1: Standard Drawing Application 3.11

3.2.2 Application 3.12: Geomembrane (GM)

Application 3.12 defines the product requirements for a „sealing element in earthworks (geomembrane)“. Geomembranes (GM) are usually manufactured of polyethylene (PE) with different densities with thicknesses of more than 1.0 mm. The minimum thickness required according to DBS 918 039 is 2.0 mm. The geomembranes are loosely placed on the area to be sealed and are then welded together. Thus they are to be regarded as technically tight barriers against liquids and gases.

Exemplarily, the following product requirements are i. a. defined:

Thickness under a load of 2 kPa ≥ 2.0 mm

Tensile Strength ≥ 15 N/mm²

Elongation at break ≥ 300 %

Dimensional Stability ≤ 3.0 %

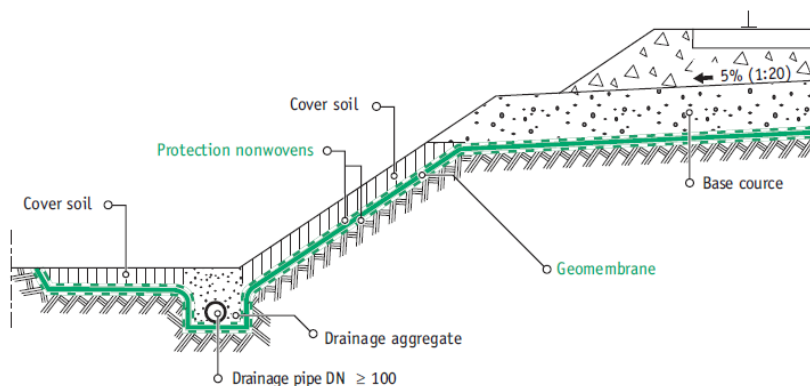


Figure 2: Standard Drawing Application 3.12

3.2.3 Manufacturer-related Product Qualification (HPQ)

The observance of the requirements of the DBS 918 039 is the basis for the approval for the use of geosynthetics in the scope of responsibility of DB AG. The HPQ process is a process applied and regulated by the DB AG to ensure the manufacturing of products, which are especially suitable for use in railway constructions with the required quality, manufacturing reliability and durability.

For the HPQ process for geosynthetics i. a. the following parameters apply:

The requirements of the DBS 918 039 must be fulfilled. The tests must be carried out by accredited test laboratories.

The duration of the HPQ is 3 years. Afterwards the HPQ has to be applied again. The test reports may not be older than 6 months.

A surveillance audit is carried out in the manufacturing plant by the quality assurance of Deutsche Bahn AG once a year.

4 INITIAL APPLICATION EXPERIENCES

In the following the first application experiences after introduction of the DBS 918 039 are shown and explained by means of selected project examples.

4.1 Upgraded line (ABS) Berlin - Frankfurt/Oder, track section Köpenick - Erkner, Germany

The upgraded line Berlin - Frankfurt/Oder runs along the track section Köpenick - Erkner and in some sections it crosses drinking water protection zones (TWSZ) of the categories II and III. For the groundwater protection the implementation planning provides i. a. the following structural measures: formation protection layer (FPL) with a base course material having a low water permeability, sealing of the track formation by means of a protection layer (placed underneath the cable duct) with a base course material having a low water permeability, sealing of the backwater area in the infiltration ditch by means of a geosynthetic clay liner. For the geosynthetic clay liner which will be used a HPQ for application 3.11 must be available. The installation is carried out in sections with a sufficient overlapping according to the installation guidelines of the manufacturer.



Figure 3: Installation of the geosynthetic clay liner in the infiltration ditch

4.2 New Line (NBS) Wendlingen – Ulm, Germany, project approval section (PFA) 2.3

The new line (NBS) Wendlingen - Ulm is part of the railway project Stuttgart - Ulm. The project approval section (PFA) 2.3 runs on the high plateau of the Swabian Alb and is for the most part located in a water protection area of zone III. Due to the karstification of the mountains on the Alb plateau, rainfalls can quickly seep into large depths. Since the discharge of water-endangering substances caused by future railway operations cannot be eliminated, a sealed system is required for the route within the approval procedure.

The route of the new line is realized by means of the slab track system and is thus sealed by means of the concrete pavement. The cut and embankment slopes are sealed with a mineral sealing layer (puddle clay).

In the area of the side walkways, i. e. between the slab track and the line drainage, geomembranes with a structured surface on both sides must be used. For the used geomembrane a HPQ for application 3.12 must be available. Additionally, the geomembrane must be protected on both sides by means of a protection nonwoven for which a HPQ for application 3.13 is required.

The geomembrane has to be tied-in into the filter (cut) or over the slope shoulder (embankment) in such a way that a sufficient overlap with the puddle package on the side of the road is ensured. The following figure shows the arrangement of the geomembrane in the side walkway.

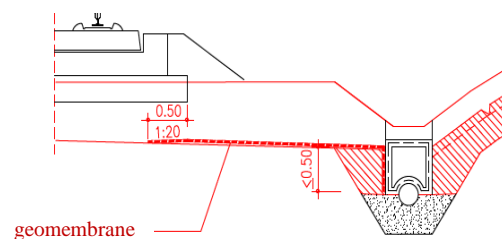


Figure 4: Arrangement of the geomembrane in the side walkway

5 SUMMARY

Since November 2015 the DBS 918 039 “Technical Terms of Delivery - Geosynthetics in Railway Construction” in the scope of Ril 836 is introduced. The applications described in the DBS 918 039 include i. a. the use of geosynthetics in groundwater protection measures (applications 3.11 and 3.12). Based on current projects in the scope of DB AG the first application experiences after introduction of the DBS 918 039 are now available - especially in the field of groundwater protection. Resulting from the extension of the guideline, the use of high-quality and permanently durable geosynthetics is now also regulated for

railway constructions in the field of groundwater protection. Thus, a reliable protection of the groundwater and the soil is ensured.

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