# APPLICATION OF MACRIT GEOCOMPOSITE IN THE CONSTRUCTION OF RAILWAY SUBSTRUCTURE IN THE CONDITIONS OF SLOVAK REPUBLIC

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## Introduction

Linear structure – Modernisation of the Trnava – Nové Mesto nad Váhom railway line in railway km 47.550 – 100.500 for cruising speed up to 160 km/h is part of European railway Corridor No. V (Venice – Trieste/Koper – Ljubljana – Budapest – Uzhgorod – Lvov). Branch A of the Corridor, 545 km long, runs through Slovakia, in the route Bratislava – Žilina – Košice – Čierna nad Tisou – the Ukrainian border.

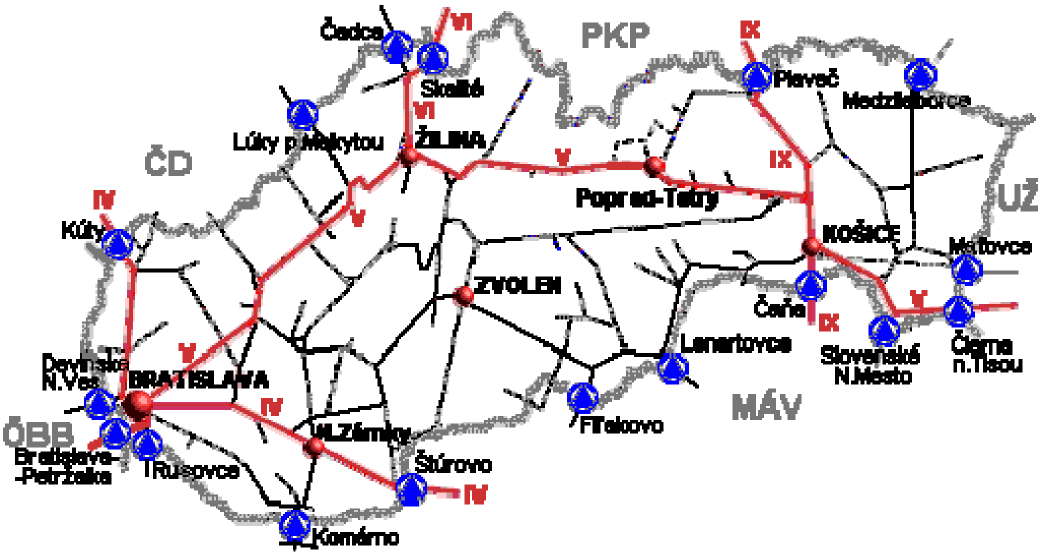


Fig. 1 Map of European railway corridors in the Slovak Republic

## Basic data characterising the construction project

The project investor and the organisation ordering design documentation is the Slovak Republic Railways (*Železnice Slovenskej republiky - ŽSR*). The principal consulting engineers are REMING Consult a.s., Bratislava. REMING Consult are at present the principal consulting engineers for a 150 km section of modernised railway lines of the Pan-European Corridor No. V in various levels of design documentation works completion.

REMING Consult a.s. is a company of consulting design engineers. It offers its clients comprehensive design and project management services in transportation, civil, housing and administrative development projects, and in engineering and industrial construction. REMING Consult a.s. was established in 1997. Its head office is in Bratislava and in 2000 the company opened an office in Žilina. REMING Consult a.s. has more than 50 full-time employees.

The main aim of the construction project is to modernise the railway line's technical infrastructure so that it meets the following parameters:
AGC – European treaty on major international railway lines (1985);
AGTC – European treaty on major routes of combined international transport (1993)

## Technical description of the design

The modernisation of the Trnava – Nové Mesto nad Váhom railway line for design speed 160 km/h involves more than 600 structures and traffic facilities. The overall length of the modernised dual track section is 52,950 metres. Four railway stations will be modernised in this section and six new train stops will be constructed. Altogether 270,264 cu.m of rail track bed material will be excavated for recycling and 1,026,598 cu.m of soil will be excavated, part of which will be used for constructing new fills and the other part will be removed and deposited. Furthermore, the project includes a reconstruction of 9 railway bridges, construction of 14 new underpasses, 3 new baggage tunnels, 11 new road bridges, 2 railway bridges, reconstruction of 11 culverts and construction of 2 new culverts and a new 100 metres long pile wall. 140,856 metres of traction mains will be constructed.

One of the most important structures will be the railway superstructure and railway substructure.

***Railway superstructure***

The modernisation of this railway will effectively amount to a complete reconstruction of the railway superstructure, as a result of:

- changed track geometry to allow for the design speed of 160 km/h;
- changed load capacity to D4 UIC (axle load 22.5 t);
- homogenisation of the railway superstructure shape along open line and station sections.

In addition, the reconstruction includes:

- removal of the gravel base in the full section;
- dismantling of the old rail-and-sleeper grid.

The homogenised main track superstructure will use:

- UIC 60 rails on concrete sleepers with flexible mountings at 600 mm "u" spans;
- thickness and section of the gravel base designed on the principle that the minimum thickness underneath the concrete sleeper bearing is 350 mm.

Station tracks will use:

- main and passing tracks will use the same superstructure construction as on open routes, i.e. UIC 60 rails on concrete sleepers with flexible mountings at 600 mm "u" spans;
- other tracks will use superstructure system S49 with 300 mm thick gravel bed underneath sleepers.

All rails along open routes and in stations will be welded into a contactless track (CT). Points in main and passing tracks must be also contactless, welded into a CT. CTs will be constructed of long rail sections and in curves with insufficient superelevation I ≥ 100 mm, used will be rails with increased resistance against wear caused by horizontal forces.

***Railway substructure***

The railway substructure design includes:

- reconstruction of the sleeper bed underneath the substructure body subgrade;
- alteration of pathways and widening of the substructure subgrade;
- widening of the earth body and in some places constructing a new earth body;
- draining the sleeper bedrock by constructing a new earth subgrade;

- removal of surface water by constructing drainage pipe systems or a trench;
- planting vegetation on the earth body;
- reconstruction of the sleeper subgrade.

The sleeper subgrade has been designed in accordance with the ŽSR methodology in force. The following limiting values of the modulus of deformation determined from static loading tests are required:

- in main tracks on the railway substructure subgrade: 50 MPa
- in passing tracks on the railway substructure subgrade: 40 MPa
- in other station tracks on the railway substructure subgrade: 30 MPa

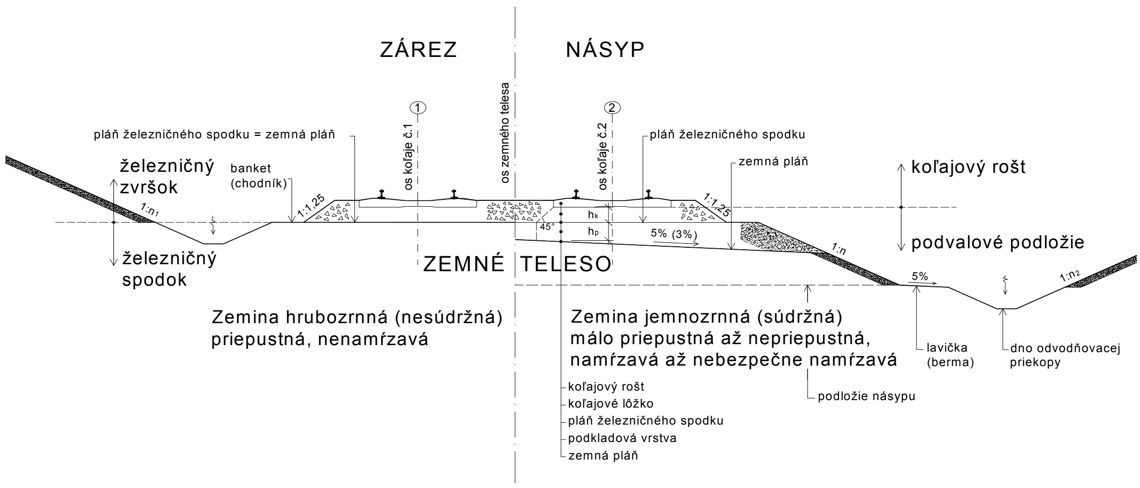


Fig. 2 Typical cross-section through the dual track railway

| | |
|---|---|
| ZAREZ | CUT |
| NÁSYP | FILL |
| pláň železničného spodku = zemná pláň | railway substructure subgrade |
| železničný zvršok | railway superstructure |
| banket (chodník) | pathway |
| os koleje č. 1 | centreline of track number one |
| os zemného telesa | centreline of the earth body |
| os koleje č. 2 | centreline of track number two |
| pláň železničného spodku | railway substructure subgrade |
| zemná pláň | earth subgrade |
| koľajový rošt | rail-and-sleeper grid |
| železničný spodok | railway substructure |
| ZEMNÉ TELESO | EARTH BODY |
| podvalové lože | sleeper bed |
| Zemina hrubozrnná (nesúdržná) priepustná, nemŕzavá | course-grain (non-cohesive) soil, permeable, not susceptible to frost |
| Zemina jemnozrnná (súdržná) málo priepustná až nepriepustná, namŕzavá až nebezpečne namŕzavá | fine-grain (cohesive) soil, low to no permeability, susceptible to dangerously susceptible to frost |
| koľajový rošt | track-and-sleeper grid |
| koľajové lôžko | track bed |
| pláň železničného spodku | railway substructure subgrade |
| podkladová vrstva | base layer |
| zemná pláň | earth subgrade |
| podložie násypu | fill subgrade |
| lavička (berma) | berm |
| Dno odvodňovacej priekopy | draining trench bottom |

A geotechnical survey of the sleeper subgrade was conducted along the entire main dual track, which determined existing values of the modulus of deformation of the earth subgrade at 200 to 600 m, by means of static loading tests. Physical and mechanical parameters of the soils were determined from the collected samples, and ground water levels were obtained from boreholes. Based on this survey, sections of identical character and load bearing capacity were divided into the so called quasi-homogenous complexes, for which the same type of sleeper subgrade construction was designed.

The railway substructure design was based on the results of the geotechnical survey, particularly on the values of the modulus of deformation of the earth subgrade, obtained from the static loading tests, from the type of soil of the earth subgrade and its properties, namely frost susceptibility and permeability. Two types of sleeper subgrade construction have been designed for the entire section, according to the earth subgrade's load bearing capacity.

In sections where the modulus of deformation reached values greater than 15 MPa and the material of the earth subgrade consisted of fine-grained and little permeable to non-permeable soils, designed was a type of sleeper subgrade with a reinforcing geocomposite and a base layer. The earth subgrade with a 3% design gradient must be thoroughly drained, treated and compacted. As the earth subgrade reinforcing geocomposite was used MACRIT GTV, a material that is composed of unwoven geotextile and reinforcing geoscreen. MACRIT GTV acts as a combined reinforcing, draining and separating component of the sleeper subgrade structure. When being installed, geocomposites are laid with the geo-textile layer on top, which will protect the geoscreen when the cover layers are being compacted. The geocomposite specified by the design is MACRIT GTV 50/50 B of 5.3 m width and 50 kN/m tensile strength, with a 12% overlap on each end and 370g/m$^2$ area weight, supplied in 100 m roles. The bed layer of crushed gravel which is applied to the geocomposite layer must be evenly compacted, and the spread and compacted base layer must not be thicker than 0.20 m. Relative density Id must be at least 0.80. For subgrade layers, the design specifies crushed gravel of 0 – 32 mm fraction, made of natural stone or recycled material. Material in the bed layers must meet the universal requirements of TNŽ 72 1514, and must not be of limestone or dolomite origin. The bed layer in the entire cross-section is in the whole section divided according to the modulus of deformation of the earth subgrade, and was determined by calculations made according to ŽSR methodology. The calculations took into account the reinforcing effect of the GTV 50/50 B geocomposite by reducing the bed layer thickness obtained from the calculation by 30%.

In sections where the modulus of deformation of the earth subgrade is lower than 15 MPa and the earth subgrade is constructed of fine-grain soil of low or no permeability, the design specifies a type of sleeper subgrade with a layer of lime to stabilise the earth subgrade, reinforced with a geocomposite and with a base layer. When the sleeper subgrade is stabilised with lime and pH factor of the stabiliser is > 9, MACRIT GTV PP 50/50 B polypropylene (PP) geocomposite must be used.

When constructing the base structural layers, care must be taken not to damage the earth subgrade (even if stabilised) or the geosynthetic material placed on top of it.

One of the advantages of using the MACRIT geocomposite is that it allows the earth subgrade to be constructed with a 3% gradient while maintaining the required properties of the earth subgrade, such as for instance good drainage. Using the 3% gradient has to a large degree reduced the volume of earthworks when excavating the railway substructure and when designing a draining trench.

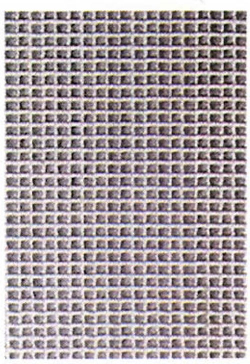

Fig. 3 The MACRIT GTV 50/50 B geocomposite

## Experience from the construction works and photo documentation

In April 2005, works on the project of modernising the Trnava – Nové Mesto nad Váhom railway line in railway km 47.550 – 100.500 for cruising speed up to 160 km/h commenced. The railway line is part of the Pan-European Railway Corridor No. V, and REMING Consult a.s., Bratislava is also the project's consulting engineer site supervisor.

The first section which has been modernised is the section between the railway stations Brestovany and Leopoldov, 4650 m long. The works commenced by refurbishing track number one. After removing the old grid of rails and sleepers, the track bed was excavated and the material recycled at recycling plants and reused. This was followed by excavating the old base layer down to the earth subgrade level, as specified in the design documentation. The earth subgrade was altered and compacted into a 3% transversal gradient. On thus altered earth subgrade the contractor performed static loading tests at 200 m intervals, which revealed considerably lower load bearing capacity of the earth subgrade than that determined from the geotechnical survey of the sleeper bed. For this reason the design of the sleeper subgrade structure had to be revised. After discussing the problem with the investor, a decision was made to increase the load bearing capacity of the earth subgrade by stabilising it either with lime or with cement. Opting for this alternative eliminated the need for additional excavation works which would have resulted in their total volume being increased, as well as the volume of the required crushed gravel in the base layer.

Results of the static loading tests carried out on the railway substructure earth subgrade substantiated the expected reinforcing effect of the MACRIT GTV 50/50 geocomposite, as well as the quality of the material used in the base layers, and also the quality of the works performed.

After it has been demonstrated that the values of the modulus of deformation on the railway substructure subgrade meet the required minima, works continued on the railway superstructure. After spreading and compacting the track bed, rail track laying operations commenced. In June 2005 the section between the railway stations Brestovany and Leopoldov, track number one, was put into test operation, followed by modernisation of track number two.

Fig. 4 Brestovany – Leopoldov, track number one, earth subgrade before reconstruction

Fig. 5 Brestovany – Leopoldov, lime stabilisation of the earth subgrade

Fig. 6   Brestovany – Leopoldov, track number one, modified and compacted earth subgrade

Fig. 7   Brestovany – Leopoldov, static loading test of the earth subgrade

Fig. 8   Brestovany – Leopoldov, laying the MACRIT GTV 50/50 B geocomposite


Fig. 9   Brestovany – Leopoldov, spreading the base layer of crushed gravel fraction 0 – 32 mm

Fig. 10 Brestovany – Leopoldov, spreading the base layer of crushed gravel fraction 0 – 32 mm in second layer

Fig. 11 Brestovany – Leopoldov, brought track bed material of fraction 32 – 63 mm

Fig. 12   Brestovany – Leopoldov, modernised section of track number one