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THE IMPACT OF WILDLIFE ON RAILWAY TRACK

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Abstract

The problem of track maintenance as a condition for the quality of railway transport in terms of comfort and speed of traffic has encouraged the modernization of railways. With modernization an important part of the process of managing the railway network is the timely identification of priority areas for maintenance and reconstruction – the so-called hot spot area. Damage to the embankment of railway structure is caused by the settlement of the railway track. Suddenly climate change leads to an increased frequency of deformations and is the most common cause of track instability. In addition to causing an increased risk to traffic safety, they can also cause serious disruptions to traffic networks. The papers present the influence of animals on deformations and damage of railway structures, primarily embankments, and the possible influence on the behaviour of track construction. The phenomenon was noticed at the end of 2020 on the railway line M104 Novska – Tovarnik – State border. As a part of the observed impacts of wild animals, continuous measurements of track subsidence at selected measuring points were carried out, and geotechnical investigation works were performed with the aim of processing and analysing the measured data and preparing a remediation project.

Keywords: railway track, wildlife, animals, damage, maintenance

1 Introduction

The earth base as an integral part of the railway's lower structure is loaded always on the same lane due to traffic, causing characteristic damage to the planum and the foundation soil (deformations in the transverse and longitudinal directions). The materials of these elements are significantly more subjected to the change compared to the elements of the railway's upper structure. The compaction of the materials within these layers caused by the traffic load must remain within the limits of elastic deformations. Various influences can cause damage. The most common are:

- method of construction of the railway substructure (unfavorable types of materials, inappropriate construction methods, insufficient and uneven compaction of the embankment, non installation of a protective layer – buffer made of unbound material);
- inadequate maintenance (irregular maintenance of the track, poor drainage of water from the planum, non-maintenance of ditches, slopes, cuts, etc.);
- increase of traffic, axle loads and speed.

Recently, we have witnessed more often that different species of animals appear in the circle of urban settlements and in various ways cause damage to the infrastructure, private properties and more.

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2 Description of the endangered section

The railway line M 104 Novska-Vinkovci-Tovarnik-State border-(Šid) is important for mixed, long-distance traffic between central and eastern Croatia. A typical lowland railway expands through the Pannonian Basin, in the zone of the river Sava. The right northern track of the railway section was originally built in 1878 and the left southern track in 1928. Almost the entire railway line was built on a low embankment with clay bases of high, medium and low plasticity. Due to their specific properties, repairs are often required. The maximum allowed mass of trains along the entire length is D4 (22.5 t/m and 8 t/m). A current maximum speed limit is 160 km/h (designed for 160 km/h).

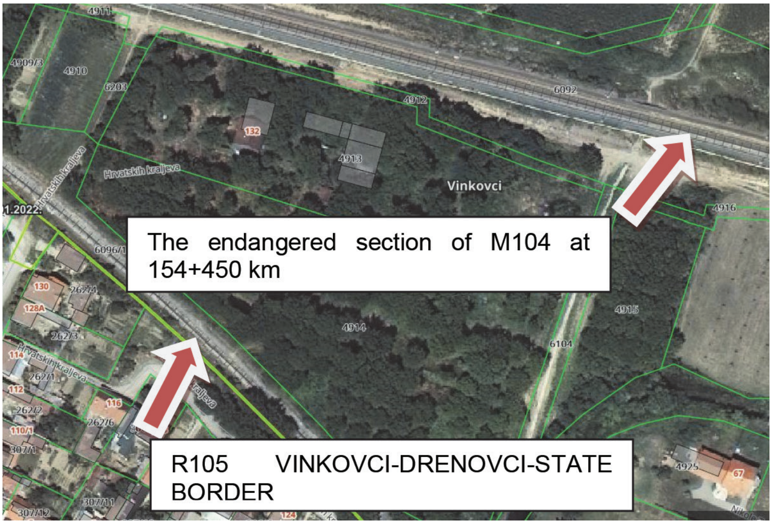


Figure 1 The endangered section of M104 Novska-Vinkovci-State border

2.1 The renewal of the railway section Vinkovci-Tovarnik-State border (2008-2010)

The last track renewal of the railway section between stations Vinkovci and Stari Jankovci was performed during the period 2008-2010. The existing track superstructure was removed, some of the earth materials were excavated to the newly designed elevation of the planum and a continuously welded track was constructed on the railway section. The rails' type 60 E1 with a strength of 900 N/mm2, prestressed concrete sleeper PB 85 and direct fastening with elastic fastenings accessories SKL-1 were installed.

Figure 2 a) 154+500-154+200 km; b) 154+200-154+500 km

The protective layer with thickness of 40 cm was made of a mixture of pure river gravel and sand compacted with vibro-compactors. The compressibility modulus at the level of the protective layer is 50 MN/m^2.

2.2 The conditions at the endangered section

At the bottom of the embankment of the right (northern) track, a part of the railway line M104 Novska-Tovarnik-State border at 154+420/470 km, damage was observed (holes excavated by wild animals (badgers, foxes, etc.)). Approximately three m3 of earth material was found next to the holes.

Figure 3 a) Badger on the track; b) Tunnel on the embankment

The embankment of the railway, built in 1928, at the site of the damage is about 3 m high. In the base of the slope, an uncoated drainage channel expands to the east, to a water duct under the railway (the watercourse of Ervenica). No damage to the embankment or track deformations were observed on the left (southern) track along the mentioned section. Based on the conducted geotechnical examination, it is estimated that the embankment of the railway is not endangered in the terms of stability at the moment. However, a measure of limitng the traffic speed to 50 km/h on both tracks at the mentioned site was implemented. To permanently solve this problem, it is necessary to repair the most affected parts or completely replace the embankment material.

Figure 4 The watercourse of Ervenica

Figure 5 The southern part of the railway line

Unmaintained nature areas are found on the south part of the urban area, between the double track railway line M105 and the regional line R105 within the urban area. On the north side, there are fields and houses. This kind of environment is ideal for badgers and other animals' dens whose natural habitat is the forest and the edges of the forest.

2.3 Geotechnical research papers and monitoring

Exploratory works and monitoring include drilling, geodetic, geophysical and laboratory works with the aim of preparing a Geotechnical Study and proposing the most optimal rehabilitation in the form of the main and detailed design. Based on the conducted research works, the following materials of the railway embankment and foundation soil were determined (groups of materials). The railway embankment include:
- embankment – ballast bed,
- clay of medium plasticity (Cl),
- clay gravel (GC).

Foundation soil include:
- clay of medium to high plasticity (CI, CH).

Groundwater is registered in borehole B-1 (S-027-21-01) at depth 4.8 m (87.09 m above sea level.), while it is not registered in the boreholes on the embankment. Exploratory drilling was performed on three boreholes.

3 Geophysical measurements

Geophysical measurements were carried out to determine the railway's condition and two geophysical methods (GPR and MASW) were applied. Based on the work carried out by the company GEOKON ZAGREB d.d., it is concluded that GPR radar did not register reflexes that would stand out in relation to the other parts of the section at approximately equal depths. However, the seismic MAWS method distinguished the changes in the dynamic characteristics of the embankment up to a depth of 4 m, which directly indicates the locations on the stretch from 154+430 to 154+460 km.
The project SMARTRAIL uses the MAWS method as one of its research methods for the TEN-T Irish Railway network. The results of the research show that the first 100 out of 300 m have a significantly lower stiffness that led to the deformations and instability. Among the other methods used for the project SMARTRAIL, the GPR (Ground Penetrating Radar) method was used to analyse the thickness and conditions of the materials, and the ERT method (Electrical Resisitivity Temography) to investigate the layers below the embankment. The depth of the research is limited to 12 m.

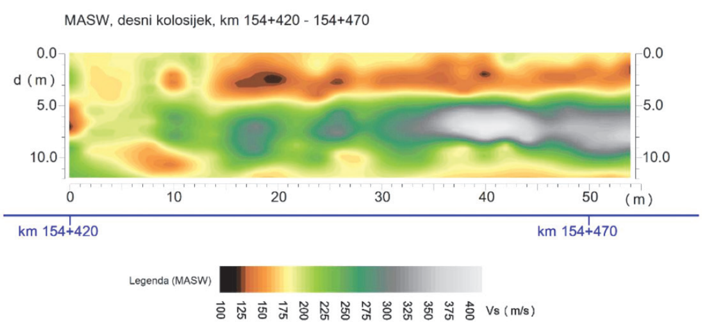


Figure 6 MASW method, right track, 154+200-154+470 km

The GPR method was performed on two profiles with lengths of 150 meters from 154+100 to 154+550 km, in the middle of both tracks. The depth of the research is limited to 4 m.

4 Analysis of measurement results

4.1 MASW (Multichannel Analysis of Surface Waves)

From 154+420 to 154+433 km, velocities in the embankment vary 160-240 m/s. According to the speeds, it can be estimated that the embankment in this part, which is built of a mixture of gravel, sand and clay, is slightly more rigid than in the rest of the investigated area. From the section 154+433 km to its end, relatively low speeds were obtained in the embankment (‹170 m/s). Therefore, these parts of the embankment have lower stiffness due to the dominance of clay in the structure. The lowest speeds have been registered at the 154+439 km and depth of 2.5 m. This can be directly related to the observed damage. Similar, but less pronounced can be said for the intervals of 154+446 and 154+460 km. From 154-429 km (the 9^{th} m of the section) to the end of the research area at a depth of 4-9 m, the velocities are greater than 220 m/s. It is a layer of foundation soil built of solid clays. Deeper than 10 m in the foundation soil, there is a layer of lower speeds (150-200 m/s).

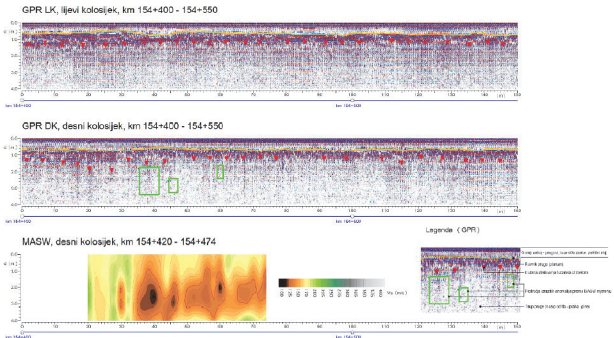


Figure 7 The GPR measures on the left and right track

To estimate better the parts of the railway with the weakest characteristics, the calculation of the relative deviation (%) of the S wave velocities from the average velocities in depth interval 0-1, 1-2, 2-3 and 3-4 m (results in Figure 8; gray shaded areas indicate places where velocities are less than the average in the layer).

4.2 GPR (Ground Penetrating Radar)

The position of the GPR LT and RT are shown in Figure 9. The results of GPR are limited to depth of 4 m, so only the embankment is affected by the cross section. It is possible to single out elements that are commonly investigated during GPR measurements on railways in the images.
The reflexes are weak in the area deeper than 1.2-1.4 m. It is difficult to single out the changes, because the embankment is made mainly of clay of relatively low resistance, high conductivity and strong attenuation of electromagnetic waves. The reasons for this can be the already mentioned signal attenuation and the nature of the damage. These are small channels, partially collapsed, with no significant changes in the electromagnetic characteristics of the material, which would lead to strong and noticeable reflexes. On the other hand, seismic MASW method distinguishes the changes in the dynamic characteristics of the embankment that can directly indicate the locations of damage.

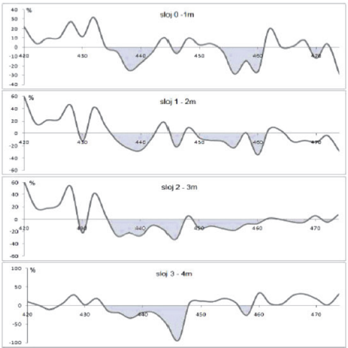


Figure 8 Anomalies – the weakest characteristics of the railway embankment

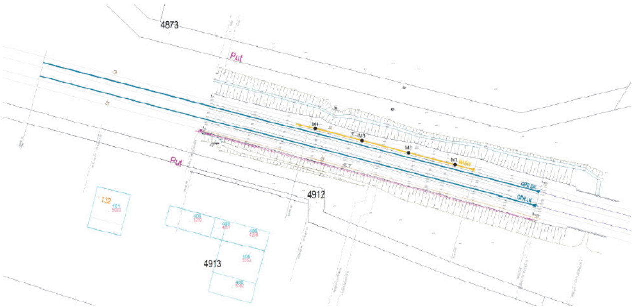


Figure 9 The position of 2D MASW I GPR LT and RT profiles

4.3 Data analysis of measuring track parameters

The graphic display of measured track level data for the part of the track 154+400-154+500 km is shown in Figure 10. At the area most often affected by animals, a subsidence is visible. The initial deformation of tracks did not change during the track level monitor time. The differences between the relative displacements obtained by successive measurements are negligible. According to the data based on the geometric usable condition of the track recording train Figures 11 and 12, the deformation longitudinal profile of the left rail is -10 is visible in km 154+448. There is also a distortion error in this parti in relation to the track in front of and behind this place.

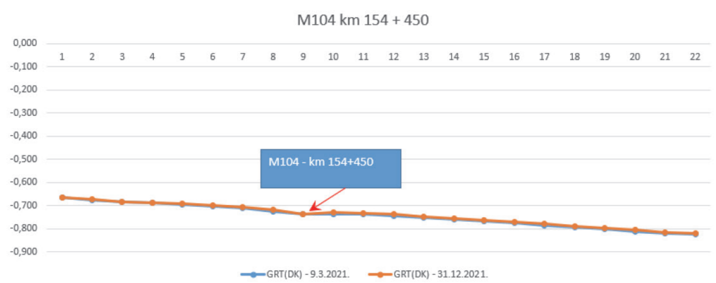


Figure 10 Track level diagram, right track, 9.3.2021.-31.12.2021

The criteria for performing the geometric usability check are:

• Category A (newly built railways), B, C (railways in regular use).

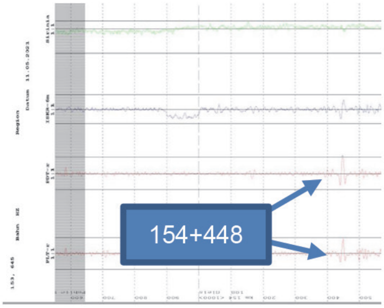
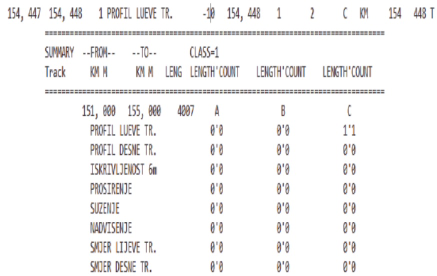


Figure 11 Graphic notation



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154, 447 154, 448   1 PROFIL LUEVE TR.      -10  154, 448   1     2      C  KM    154   448 T
      ================================================================================
      SUMMARY  --FROM--    --TO--       CLASS=1
      Track      KM M        KM M   LENG  LENG'TH'COUNT    LENGTH'COUNT    LENGTH'COUNT
      ================================================================================
              151, 000  155, 000   4007    A               B               C
                PROFIL LUEVE TR.          0'0             0'0             1'1
                PROFIL DESNE TR.          0'0             0'0             0'0
                ISKRIVLJENOST 6m          0'0             0'0             0'0
                PROSIRENJE                0'0             0'0             0'0
                SUZENJE                   0'0             0'0             0'0
                NADVISENJE                0'0             0'0             0'0
                SMJER LIJEVE TR.          0'0             0'0             0'0
                SMJER DESNE TR.           0'0             0'0             0'0
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Figure 12 Numerical notation

For category C railways in regular use, 10 represents the limit value for track class for speeds 140-160 km/h, while for category B it belongs to rail class 5 for speeds of 61-80 km/h, or for category A rail class 6 for speeds of 41-60 km/h. The average TQI (Track Quality Indeks) for the km 154+000 to 155+000 is 4.9, the maintenance TQI is 10. The reduction in velocity depends on the magnitude of the error according to the Category C criteria and the estimate of the possible deterioration.

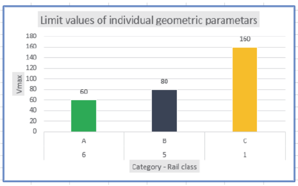

Figure 13 Limit values of individual geometric parameters

4.4 Causes and consequences

In addition to the processed action, we will give some one more examples with possible consequences. The aim is to point out the possible consequences of the joint action of climate change and animals. Beavers close the gaps of water duct by creating habitats for life. With the sudden flow of water through the water duct (Figure 14), vortexing occurs on the other side and craters form. Figure 15 shows a crater caused by clogged water duct during a major flood due to the overflow of the Sava River.

Figure 14 Water duct buried

Figure 15 Damage caused by floods

5 Conclusion

The railway maintenance is mainly aimed at eliminating damage and deficiencies caused by traffic load and age. Climate and lifestyle changes, exploitation of forests and natural habits are leading to changes in natural flows. Various species of animals are increasingly entering the populated areas and organizing spaces for their existence. Untimely observation of these natural changes with the impact of climate changes can cause the destruction of the existing infrastructure and have catastrophic consequences, in this case on the safety of railway transport. The reconstruction of railways is mainly focused on the installation of a higher quality permanent way. The problem of insufficient bearing capacity is being compensated with new types of materials (geotextiles, geogrids, etc.). Based on the observed actions of animals and conducted research work, considering the characteristics of the location and possible interventions, the following guidelines and recommendations are given:

- On the subject line there was a weaking of the embankment caused by the wild animals;
- It is proposed to completely replace the embankment material on the right (northern) track as a permanent remediation measure;
- After the remediation, the slope is protected from wild animals with steel mesh.

A simple cause of damage can lead to a reduction in the capacity of the infrastructure system and ultimately an expensive technical remediation. The construction profession is able to repair the consequences of these actions in a certain time period. However, without a timely identification and elimination of the causes, the damage can be repeated. The state of the extraordinary, atypical events puts maintenance workers at a disadvantage compared to standard maintenance procedures in order to maintain safe traffic. Extreme situations are happening every day and it is required to improve and establish new views on these issues and include all relevant factors of the society and communities to preserve important life conditions.

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