EIA EVALUATION OF THE HIGHWAY CONSTRUCTION D3 – ŽILINA (NOISE, VIBRATION AND TECHNICAL SEISMICITY)

HODNOTENIE EIA PRI VÝSTAVBE DIAĽNICE D3 – ŽILINA (HLUK, VIBRÁCIE A TECHNICKÁ SEISMICITA)

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Abstract

The aim of this paper is to present the criteria requirements in the EIA process in order to select the optimal alternative with respect to the impact of noise, vibration and technical seismicity from feasible alternatives of the highway construction D3 Žilina / Brodno – Kysucké Nové Mesto. The highway with a tunnel alignment of the road lines is compared to the elevated one. The zero option is documented and then compared to the other solutions of the D3 highway construction in case of their implementation.

Abstrakt

Cieľom príspevku je prezentácia tvorby súboru kritérií v procese EIA na výber optimálneho variantu s ohľadom na dopad hluku, vibrácií a technickej seizmicity pre variantné riešenie výstavby diaľnice D3 Žilina / Brodno – Kysucké Nové Mesto. Variant výstavby diaľnice s tunelom je porovnaný s variantom výstavby diaľnice s estakádou. Nulový variant je zdokumentovaný a následne porovnaný s variantnými riešeniami výstavby diaľnice D3 v prípade ich realizácie.

Keywords: EIA, impact of noise, vibration, highway construction

Kľúčové slová: EIA, vplyv hluku, vibrácie, výstavba diaľnice

1 Introduction

This paper demonstrates the monitoring results of the danger option verification of the existing building objects due to the ground and building vibration in neighborhood to the prospective highway road line D3. The hazard rate option of building objects by horizontal alignment of the prospective highway road line D3 was examined under the name "alternative B3 – surface" and moreover the option of the tunnel alignment of the road line was taken into consideration as well.

The particular highway construction is in the category of D 24.5/80 in the direction Žilina (Brodno) – Kysucké Nové Mesto. It is part of the highway road line D1 – D3 in direction Bratisava – Žilina – Skalité and the multimodal transport corridor No.VI., Trans European networks and main line in direction north-south.

The dynamic response caused by the ground and building vibration in case of the steady periodic loading does not have to be further analyzed as far as at the reference point the effective particle velocity does not exceed the limit values of the effective velocity \dot{v}_{ef} (mm. s⁻¹). If the velocity values cannot be achieved at the reference point or directly at the building construction by measurement, it is possible to apply the attenuation law for the rail and road traffic and for the ground and building vibration. According to the attenuation law it can be determined for the sources situated in different distances whether the ground and building vibration has a certain impact on the surveyed object from the viewpoint of the limit state.

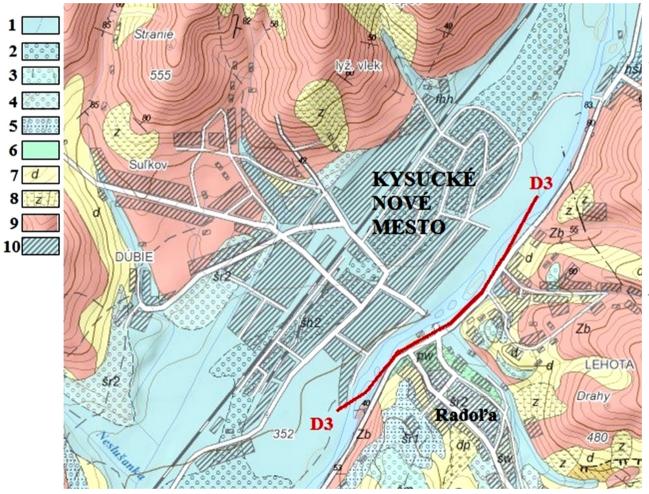


Fig. 1 Geological map of the surrounding environment of the surveyed road line D3 Žilina (Brodno) – Kysucké Nové Mesto.

The surveyed road line is marked by the red line [1]. Post-Tertiary: 1- fluvial and proluvial sediments: clay and gravey clay of the stream bottomland, 2- gravel and gravey clays of the stream bottomland, 3- fluvial sediments: gravel and sandy clavey graves of the upper terraces 4- fluvial sediments: sandy graves of the lower middle terraces, 5- fluvial sediments: gravel and sandy sporadically clayey graves of the upper middle terraces, 6proluvial sediments: clayey graves with cuts (alluvial cones), 7- deluvial sediments: nonstructured hillslope and debris as a complex, mainly clayey and stony-clayey hillslopes, 8deluvial sediments: non-structured hillslopes and debris as a complex, mainly clayey and stony-clayey hillslopes, Paleogene: 9- Zlínske complex of strata bystrické layers - bystrické claystones, glaucomitic sandstones, arkosic sandstones, 10-building territory

2 Transmitting media and measurement methodology

The geological conditions (rock environment – transmitting medium) in the surveyed section are relatively monotonous. They are fluvial sediments of the river terrace of the river Kysuca. There can be mainly found horizontally lying gravel, sandy gravel, clayey graves and clay (Fig. 1). From the seismic waves transmission point of view the environment has high attenuation as far as it is not irrigated. Generally the water presence in this particular rock medium means increasing the level of the seismic waves transmission.

For the purpose of the impact prediction of the prospective highway operation D3 the impact of the bridge expansion joints was measured on the peak particle velocity value D3 v_{peak} at the measuring point V1 at the beam under the ruined bridge expansion joints and at the measuring point V2 on the concrete board on distance 25 m (Fig. 2, Fig. 3) from the ruined bridge expansion joints during the passage of the cars and trucks. These measurements (Table 1, Table 2) showed the eventual peak particle velocity values during the passage of the trucks and cars at the highway operation D3 (Fig. 4, Fig. 5).



Čadca at the beam under the ruined / functional bridge expansion distance 25 m from the bridge expansion joints joints



Fig. 2 Measuring reference point V1 at the elevated highway in Fig. 3 Measuring reference point V2 on the concrete board on

Table 1 Measured ranges peak values of the particle velocity v_{peak} at the measuring points V1 and V2 during the passage of the trucks at the beam with the ruined expansion joints

1		
	V1 [mm. s ⁻¹]	V2 [mm. s ⁻¹]
X	1 – 6	0.01 - 0.10
Y	1 – 5	0.02 - 0.08
Z	1 – 2	0.04 - 0.09

Table 2 Measured ranges peak particle velocity values v_{peak} at the measuring points V1 and V2 during the passage of the cars at the beam with the ruined expansion joints

1 2		
	V1 [mm. s ⁻¹]	V2 [mm. s ⁻¹]
X	0.5 - 1	0.005 - 0.010
Y	0.5 - 1	0.005 - 0.010
Z	0.5 - 1	0.010 - 0.020

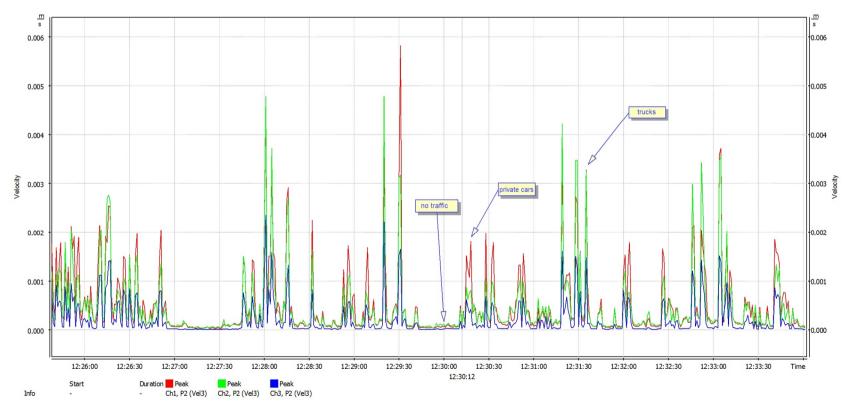


Fig. 4 Time response of the peak particle velocity value v_{peak} in direction X Y and Z during the passage of cars and trucks at the measuring point V1 at the beam of the ruined bridge expansion joints

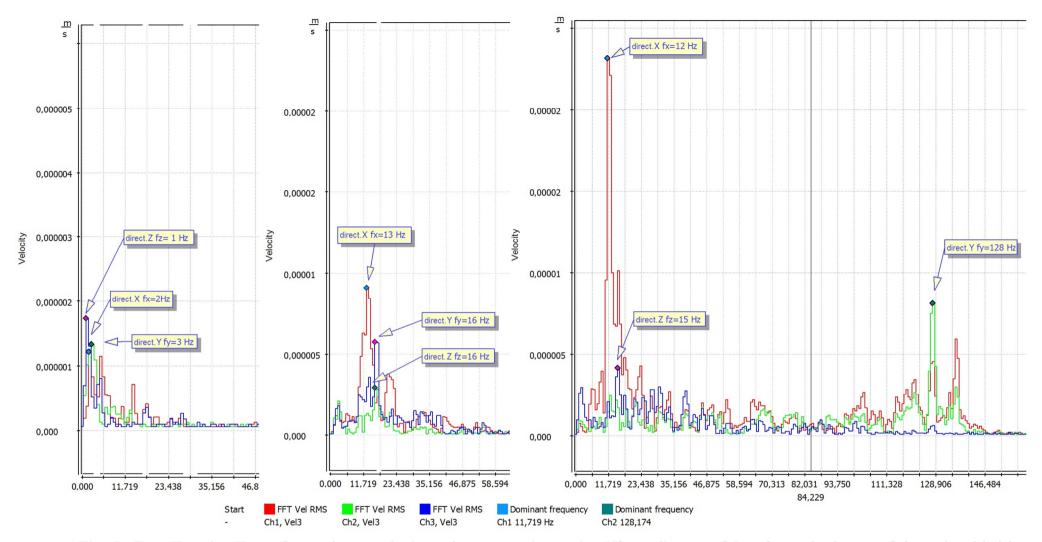


Fig. 5 Fast Fourier Transformation analysis at the measuring point V2 on distance 25 m from the beam of the ruined bridge expansion joints without and with passages of cars and trucks through the bridge expansion joints

To determine the seismic waves attenuation law [2], whereby the source of the waves is the passage of the automobiles along the road, we carried out measurements of the passages of automobiles along the road communication I/11 at the elevated highway in Čadca at the measuring point V1 at the beam under the bridge expansion joint ruined/ functional and at the measuring point V2 on the concrete board on distance 25 m from the bridge expansion joint defining the effective \dot{v}_{ef} and peak particle velocity value v_{peak} .

Due to these measured values the seismic waves attenuation law was determined from trucks, see Fig. 6.

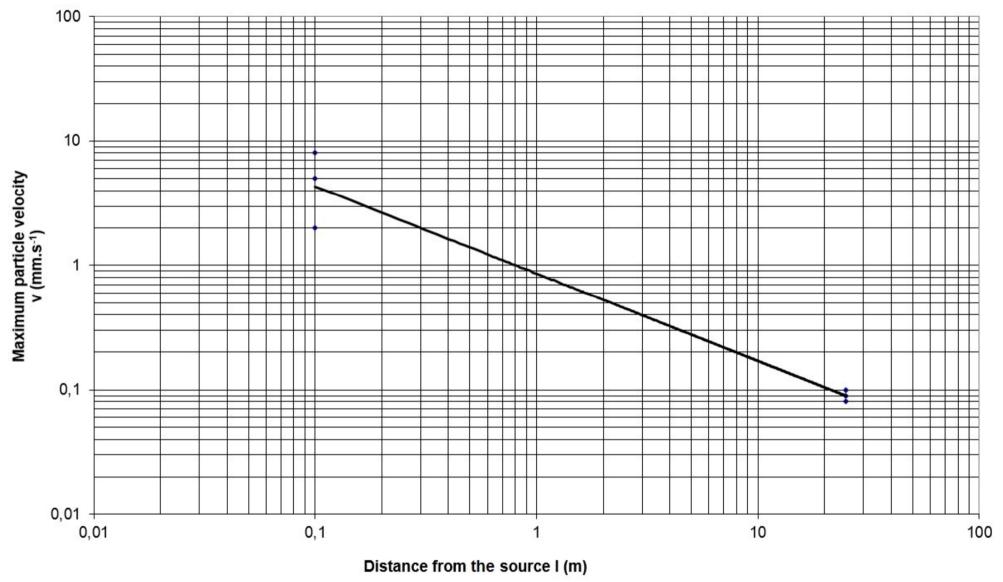


Fig. 6 Seismic waves attenuation during the passage of the trucks along the road communication

To establish the impact of the seismic waves on the tunnel alignment of the road line, it was necessary to measure the tunnel portal impact on the peak particle velocity value v_{peak} at the measuring point T1 (Fig. 7) at the tunnel portal "Čadca Horelica" and at the measuring point T2 (Fig. 8) on the concrete board on distance 25 m from the tunnel portal during the passages of the cars and trucks at hourly profile 1416 vehicles, from which there were 402 trucks.

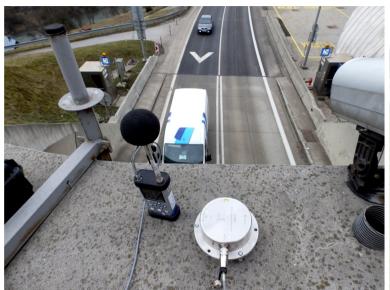




Fig. 7 Measuring reference point 2 – point T1 at the Fig. 8 Measuring reference tunnel portal "Čadca Horelica" point 2 – point T2 on the

Fig. 8 Measuring reference point 2 – point T2 on the concrete board on distance 25 m from the tunnel portal during the passages of the cars and trucks

Table 3 Measured ranges peak particle velocity values v_{peak} at the measuring points T1 and T2 during the passages of the trucks at the tunnel portal and on distance 25 m from the tunnel portal during the passages of cars and trucks through the tunnel

	T1 [mm. s ⁻¹]	T2 [mm. s ⁻¹]
X	0.02 - 0.08	0.02 - 0.08
Y	0.02 - 0.04	0.02 - 0.08
Z	0.02 - 0.08	0.01 - 0.03

3 Impact of the passages along the road communication I/11 on the effective and peak particle velocity

There was assessed the impact of the passages along the road communication I/11 in the village Budatinska Lehota at the measuring reference point V1 on distance 7.5 m from the closest traffic lane (CTL) and at the measuring reference point V2 on distance 25 m from CTL at the foundation construction of the family house (Fig. 9, Fig. 10, Fig. 11). The hourly profile is as follows: total – 1014 cars and 402 trucks.



Fig. 9 Measuring reference point V1 on distance 7.5 m from CTL

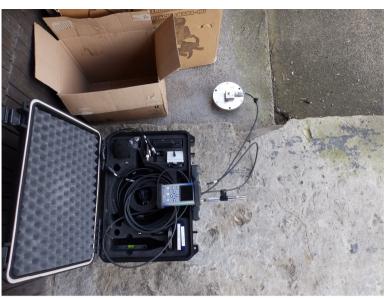


Fig. 10 Measuring reference point V2 on distance 25 m from CTL at the foundation construction of the family house



Fig. 11 The family house for the reference point V2

Table 4 Measured values of the effective vibration velocity $\dot{ extit{v}}_{ extit{e}f}$ at		
the measuring points $V1$ and $V2$ during the passages of the		
trucks and cars at the passages along the road communication		
I/11 in the cillage Butanínska Lehota		

Communicatio n I/11 passing clearance I/1h 1416, 402 NA	Point V1 on distance 7.5 m [mm. s ⁻¹]	Point V2 on distance 25 m [mm. s ⁻¹]
X	0.010	0.010
Y	0.010	0.007
Z	0.030	0.010

Table 5 Measured values of the peak particle velocity $v_{\rm peak}$ at the measuring points V1 and V2 during the passage of the trucks and cars at the passage of the road communication I/11 in the village Budatínska Lehota

	Point V1 on distance 7.5 m [mm. s ⁻¹]	Point V2 on distance 25 m [mm. s ⁻¹]
X	0.2	0.1
Y	0.3	0.1
Z	0.5	0.2







the family house – in the children's

The vibrations were measured by monitoring, during the highway construction by the tunnel alternative (Table 3, Table 4, Table 5), in the housing object situated in the economic zone of the highway construction, furthermore the vibrations were measured in the early morning, morning, afternoon, evening and at night times (Fig. 12, Fig. 13).

The vibrations lasted within 8 – 12 seconds with 19 - 53 shock impulses. As there was a repeated long-lasting (more than 500 ms). At 8 - 12 seconds lasting vibrationswith repeated shock impulses there occured the steady periodic loading of the surveyed object, which at exceeding the limit values [2, 3, 4] of the effective particle velocity $\dot{v}_{ef} = 1.0$ mm. s⁻¹, could have damaged the surveyed object. The

example of the measured values is depicted in the seismograph, see Fig. 14, Fig. 15.

In accordance with the Decree of the Ministry of Health of SR No. 549/2007 [7], Table 4 for living rooms, hostels, retirement homes, the following reference time interval is valid: Permissible by norm No. 549/2007 a_{wmax,p} [m. s⁻²]: evening 0.11, night 0.05, daytime 0.11. Observe values: evening 0.263, night 0.156, daytime 0.257.

The following parameters (the examined value – the measured value of the defining vibration acceleration extended by the measurement uncertainty U) were determined in accordance with the metrological praxis i.e. 20 % due to the measured values derived vibration acceleration in the internal building environment $a_{Rwmax,T} = (a_{wmax,T} + U)$.

4 Evaluation of the potential impact on health - noise

The sound level in the external area of the economic zone of the highway D3 Žilina (Brodno) – Kysucké Nové Mesto is reviewed for the assessment ratio EIA according to the law of the National Council of the Slovak Republic No. 355/2007 Coll., Act of the Government of SR No. 339/2006 Coll. by which the Decree of the Ministry of Health of SR No. 549/2007 Col. is complemented and the Decree of the Ministry of Environment of SR No. 113/2006 Coll. by which is the Act No. 24/2006 Coll. amended and complemented [5, 6, 7, 8, 9, 10, 11].

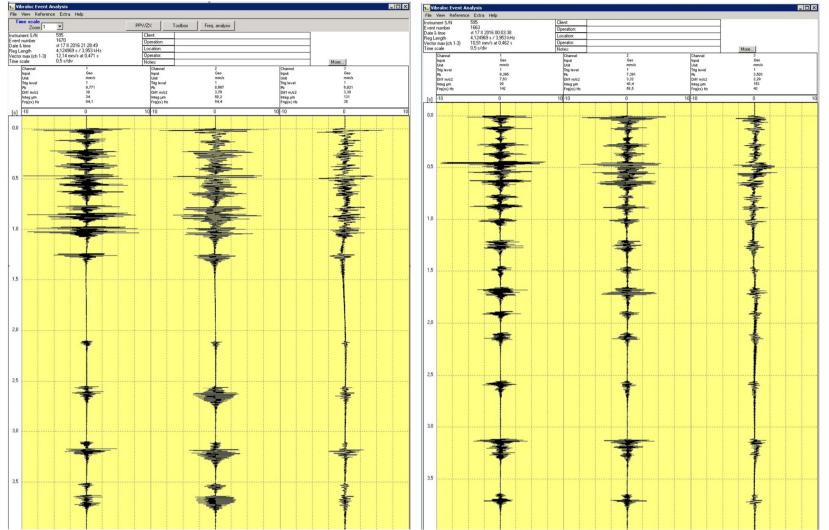


Fig. 14 Graphic record of the vibration acceleration Fig. 15 Graphic record of the vibration acceleration of the individual components in longitudinal, of the individual components in longitudinal, transversal and vertical directions, measured at the transversal and vertical directions, measured at the measuring point housing object at 21:28 h with measuring point housing object at 00:03 h with particle velocity values $v_{xpeak} = 9.9 \text{ mm. s}^{-1}$ at f = 54 Hz particle velocity values $v_{xpeak} = 9.4 \text{ mm. s}^{-1}$ at f = 142 Hz

The assessment of the noise control measures was reviewed in the 3D model by verified and calibrated 24hour measurement in-situ. applying the graphical visualisation of the sound pressure level in three alternatives:

- Alternative 01 without construction realization of D3 (without any noise control measures)
- Alternative 02 tunnel alternative ofD3 (updating of the Case Study: Noise Study of the Highway D3Žilina / Brodno – Kysucké Nové Mesto – proposal on noise control measures.
- Alternative 03 alternative of the highway construction D3 at the elevated highway.

The proposal on noise control measures was implemented for the Alternative 03, for prognosed period – the years

2022 and 2032. The noise from the traffic at the particular section of the highway D3 has an ineficient impact on the sound level in the suburban area of the city Kysucké Nové Mesto, the villages Radol'a and Budatínska Lehota. Therefore it will be necessary to take measures

as the proposed secondary and tertiary noise control measures on decreasing this negative phenomenon (replacement of windows with controlled ventilation system etc.).

According to the analytical map of the acoustic domain in the economic zone derivable from the noise emissions of the mobile sources of the road traffic (Fig. 16), it can be pointed out that due to the limits of the permissible values (PH) of the noise from the road and water traffic for the area categories II. and III., in the external area of the living space of the flats and family houses [7]:

for the daytime the permissible value is not exceeded,

for the evening time the permissible value is not exceeded,

for the night time the permissible value is not exceeded.

5 Conclusion

According to the presented documentation and measured values of the vibration it can be pointed out that in the surrounding environment of the prospective road communication D3 Žilina, Brodno – Kysucké Nové Mesto both the housing objects and the sewage treatment plant will be exposed to a long-lasting vibration impact from the road traffic (eventually to a permanent loading). In case of the completed construction the beams, on which the road

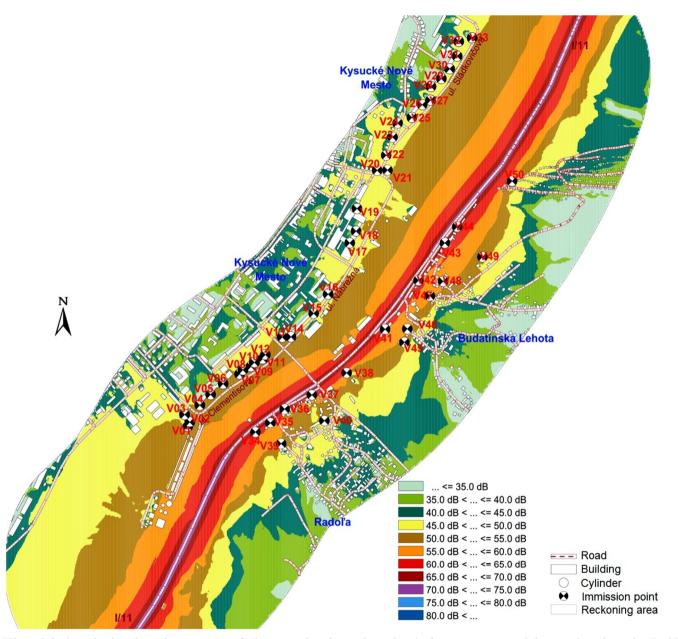


Fig. 16 Analytical noise map of the equivalent levels A demonstrated by noise levels 5 dB $L_{pAeq,12h,day}$ at daytime from 22:00 to 06:00 h., at the height 4.0 m above the terrain, in the external area of the dwelling territory from acoustic – emission radiation of the road traffic

communication will be constructed, and the operation of this road communication will be the source of the vibrations. The stream aluvial sediments of the river Kysuca create the transmitting medium. In this particular environment there occurs the seismic waves attenuation because there can be found a soft rock medium. In case of its irrigation there will be an increased ability of seismic wave transmission at 1/3. The level of groundwater will be dependent on the water level of the river Kysuca. We suppose that it comes to the environment irrigation up to 1 m from the surface.

Consequently due to these facts the transmitting medium can be categorized as follows: category A (in accordance with the Eurocode 8 STN EN 1998-1/NA/Z1, [8]).

The housing objects will be situated in a longer distance than 20 m from the beams, on which the highway will be constructed. According to the preliminary measurements the peak vibration velocity in this given distance is lower than 0.03 mm. s⁻¹ and the effective particle velocity is lower than 0.01 mm. s⁻¹. These values (increased vibration values) were not exceeded either in case of the ruined bridge expansion joints and are safe for the housing objects from the viewpoint of danger option.

In case of sewage treatment plant the road communication is planned in a distance shorter than 20 m. Two beams are planned in the close neighborhood to the sewage treatment plant (up to 10 m). The measured values of the peak particle velocity values under the ruined bridge expansion joints did not exceed 0.2 mm. s⁻¹ and the effective values were lower than 0.1 mm. s⁻¹. The vibration velocity proves a decreasing tendency in connection with the increasing distance and in distance 25 m the peak particle velocity value is lower than 0.01 mm. s⁻¹. Due to these data we can confirm that these values are low but we are not able to assess the impact on the machinery used in the sewage treatment plant (sensitivity of the machinery in case of the seismic loading – the operator of the sewage treatment plant is responsible for the sensitivity identification of the machinery). Eventually after the activation of the road communication D3, it will be further required to carry out check scaling of the machinery of the sewage treatment plant.

In case of the tunnel alignment of the road line there occured repeated long-lasting (more than 500 ms). The examined value of the vibration velocity parameter was exceeded. Therefore it is necessary in case of the tunnel alignment of the road line to decrease the particle velocity values up to a level at which the permissible value would not be exceeded.

The sound level in the external area of the surveyed territory of the highway D3 Žilina (Brodno) – Kysucké Nové Mesto meets the requirements on the tunnel alignment of the road line. In case of the prospective elevated highway it will be unavoidable to take secondary and tertiary noise control measures.

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