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Road and Rail Infrastructure III

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RAIL TRAFFIC NOISE PROTECTION IN CROATIA – CHALLENGES DURING THE FIRST APPLICATION

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Abstract

In order to upgrade the track structure for train speed of up to 160 km/h, approximately 62 km long section of railway line Oštarije-Knin-Split is in process of reconstruction. To complete the reconstruction, noise protection and railway level crossings safety features need to be incorporated on the track. This paper presents the process of rail traffic noise protection project creation. Project predicts both active and passive noise protection measures – construction of noise protection walls and building isolation. Noise protection walls described in this paper will be the first rail noise protection structures on Croatian railway network.

Keywords: rail traffic noise, environmental protection, concrete noise wall

1 Introduction

In order to upgrade the track structure for train speed of up to 160 km/h, approximately 62 km long section of Lika railway, i.e. section from station Perušić to Gračac of railway line Oštarije-Knin-Split (shown in Fig. 1) is in process of reconstruction. As final part of the reconstruction project, rail noise protection must be designed. This task has been entrusted to the Department for Transportation Engineering of Faculty of Civil Engineering Zagreb.

According to [1], traffic noise from newly built and reconstructed transport infrastructure such as railways, state or county roads, that adjoin or intersect the residential, business, vacation, recovery and treatment areas should be designed and constructed in such a way that the noise level at the border of planned transport corridor does not exceed the equivalent noise level of 65 dB (A) during the day and 50 dB (A) at night. According to [2], if predicted rail traffic noise levels, calculated by “interim” noise computation method – Dutch National Method RMR-SRM II, should exceed prescribed values, mitigation measures must be carried out.

Commonly used method of rail noise control both on existing and new railway lines is construction of noise walls next to rail tracks, often in combination with building noise insulation. Typical noise reductions after wall installation are up to 10-15 dB [3] depending on the wall height, absorption and its distance to source and receiver. A survey conducted by UIC [4] showed that, by the end of 2005, more than 1.000 km of noise walls were constructed and more than 1.25 million Europeans have noise protection through insulated windows. An estimated total of 150-200 million euros are spent annually in Europe on noise walls and insulated windows. Same measures of noise protection will be used on this section of Lika railway.

Figure 1 Section from station Perušić to Gračac of railway line Oštarije-Knin-Split

Project assignment dictates design of noise protection exclusively for buildings near open rail track sections, while areas around three rail stations (Perušić, Gračac and Gospić, Fig. 1) are excluded from consideration. The project of rail traffic noise protection is divided into three parts:

- noise protection study which contains acoustic modelling of the observed area and results in optimal definition of noise protection wall's height and its placement in rail plan;
- noise protection wall main design which contains elaboration of its elements and positioning in vertical plane and
- proof of proposed protective construction mechanical resistance and stability which contains calculation and dimensioning of noise protection wall elements.

Although the procedure of noise protection design and construction during (re)construction of road infrastructure has become common and well known during the last years, as this is the first case of noise protection application on Croatian railway network, during the project development few challenges emerged. These challenges, as well the procedure of three-part project creation will be briefly presented in the following sections.

2 Creation and results of noise protection study

In order to perform the acoustic analysis and determine the optimized wall height and length, placement of wall in rail track cross section had to be established. To achieve optimal performance of the noise wall, a general rule is to place it as close as possible to the source or to the receiver.
Two challenges emerged while predicting the wall's location in railway cross sections. The first was non-existent national regulations regarding noise wall placement along the tracks i.e. its minimum distance from track axis. Draft version of such a document states that the distance between rail track and wall axis must be greater than 4 meters. This demand, although unofficial, created another problem.
According to project task, walls must be constructed on the rail reserve. The lack of free space between the nearest rail and rail corridor boundary for wall structure placement, i.e. already built drainage elements and telecommunication installations, in many track sections made wall introduction impossible (Fig. 2). After considering specifications defined in Italian and German national regulations, Investor decided to reduce the permissible minimum distance to 3.6 meters (Fig. 2).
Finally, it was time to optimize the planned noise protection. Since the track section is under reconstruction, rail traffic is carried on a reduced scale and with limited train operational speed (Table 1), study predicts two phases of noise protection construction.
Phase I includes the noise protection measures (both passive and active) that must be implemented immediately, even in these exceptional rail traffic conditions. The construction of phase I noise protection walls and building isolation coincides with completion of rail level crossings safety measures incorporation, i.e. marks the end of rail section reconstruction. After planned protection in phase I is constructed, it will be necessary to conduct acoustic field measurements in order to determine the effect of preformed protection measures.

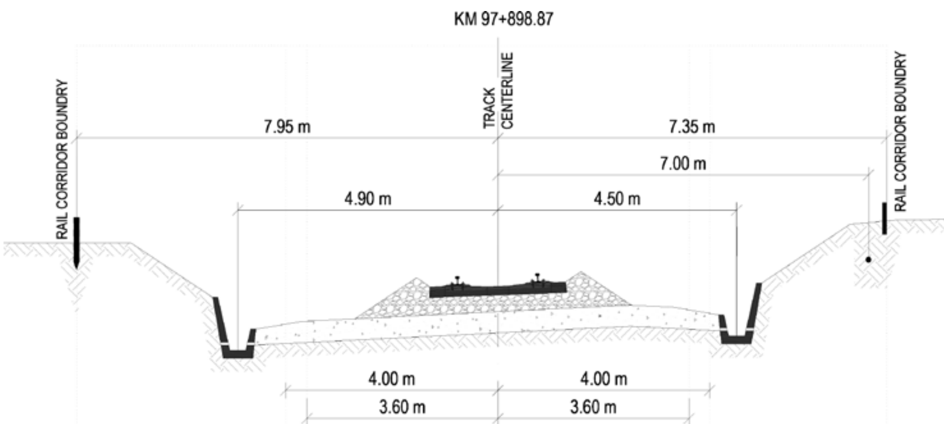

Figure 2 Typical cross-section of Lika railway from Perušić to Gračac

Table 1 Noise modelling input data regarding rail traffic in operation during reconstruction

Train category	Design speed	Max speed	Number of trains during		
			Day	Evening	Night
	[km/h]	[km/h]	07 – 19 h	19 – 23 h	23 – 07 h
Passenger	100	100	5	0	4
Freight	80	80	7	2	3

Because the completion of track reconstruction implies an increase in rail traffic volume and speed (Table 2), the study further predicts the necessity of the implementation of the phase II protection whose construction should start immediately after the completion of phase I.

Table 2 Noise modelling input data regarding rail traffic in operation after reconstruction

Train category	Design speed	Max speed	Number of trains during		
			Day	Evening	Night
	[km/h]	[km/h]	07 – 19 h	19 – 23 h	23 – 07 h
Passenger – tilt	160	110-160	8	0	0
Passenger – conventional	120	80-120	2	2	6
Freight	80	80	8	2	3

Table 3 shows the height, length and area of optimized noise protection walls of protection phase I and II.

Table 3 Dimensions of optimized noise protection walls – phase I and II

Wall height	Phase I		Phase II	
	Lenght	Area	Lenght	Area
H [m]	L [m]	A [m²]	L [m]	A [m²]
1.0	0	0	24	24
1.5	20	30	96	144
2.0	100	200	184	368
2.5	212	530	16	40
3.0	80	240	24	72
3.5	0	0	12	42
Total	412	1000	356	690

According to the investor's decision, individual residential buildings located at a minimum distance of 150 m from the adjacent buildings are not intended for protection by noise protection walls. Such facilities will be protected by passive noise protection measures. In addition, the study showed that passive protection should be applied on objects close to the rail level crossings. Noise modelling results showed that 19 residential buildings are in need of noise insolation.

3 Creation and results of wall's main design

While deciding about the type and materials of wall's construction, factors such as limited space in rail cross section, available construction technology, aging/corrosion, stone impact and fire resistance were taken into account. Therefore, project predicts the construction of the walls with steel columns, supported by concrete piles and fill slabs made out of precast concrete. In most countries, precast concrete is the most commonly used wall material, providing low cost, low maintenance and effective solutions to unwanted noise. This is because concrete noise protection walls [5]:

- are durable, with a design life of at least 40 years;
- require minimal maintenance and low whole life costs;
- can act as safety walls, withstand elements, fires and vandalism;
- take up less space than earth mounds;
- are made from locally produced materials;
- can be designed for installation at a variety of angles – vertical, raked or mixed;
- move from being an exposed structure to acting as embankment stabilizers in a continuous ribbon;
- are flexible in design – can have any profile, colour or size can and therefore provide elements of architectural interest;
- are plant friendly – they contain no preservatives and need no repeat treatment.

4 Creation and results of wall's mechanical resistance and stability calculations

While calculating the mechanical stability and resistance of wall structure the following three effects were observed:

- structure dead load together with additional constant load (weight of the absorbing layer of wall fill slabs) in the value of 1.9 kN/m^2;
- wind pressure in its maximum value of 1.37 kN/m^2 (for construction located in wind zone III and at an altitude of 560 meters above the sea level wind speeds are up to 35 m/s) [6];
- rail vehicle pressure – this is yet another challenge that needed to be solved, because, again, there is no national legislation covering this topic. The answer was found in German researches and practice. According to [7], the maximum value of pressure and suction for train passing speed of 200 km/h is 0.35 kN/m^2. This value is considerably lower than wind pressure. Considering that the maximum train speed on reconstructed section of Lika railway will be 160 km/h and that regulations require that wind and vehicle pressure are not to be taken into calculation simultaneously, wind pressure was defined as the relevant load for wall's mechanical resistance and stability calculations.

Due to the possibility that the results of acoustic measurements preformed after the construction of the phase I walls will show a need to increase the overall height of the walls, all the calculations and dimensioning of construction elements were performed for 0.5 m higher walls. When calculating and dimensioning of piles, data on soil characteristics contained in the geotechnical study [8] was applied. Calculations were done considering the characteristics of the soil that is prevalent in a particular area. This is because the distances between the investigation points described in the study were quite large. However, since it is possible that, in some places, piles will enter the solid rock, two principles of calculating and dimensioning were conducted:

- the pile is hovering in infinite half-space – calculations were conducted by the theories and data of [9, 10, 11, 12];
- the pile is wedged into solid rock in depth of 1.2 meters – calculations were conducted using the finite element method and Winkler soil model.

Calculations showed that the foundation construction of the noise protection walls must consist of piles 0.6 meters in diameter and from 3.5 to 5.0 meters in length. At the top of the pile there should be specially shaped patella for steel pillars in depth of 0.9 or 0.7 meters. The thickness of the supporting layer of reinforced concrete fill slabs must be 0.12 meters. Wall construction is shown in Fig. 3.

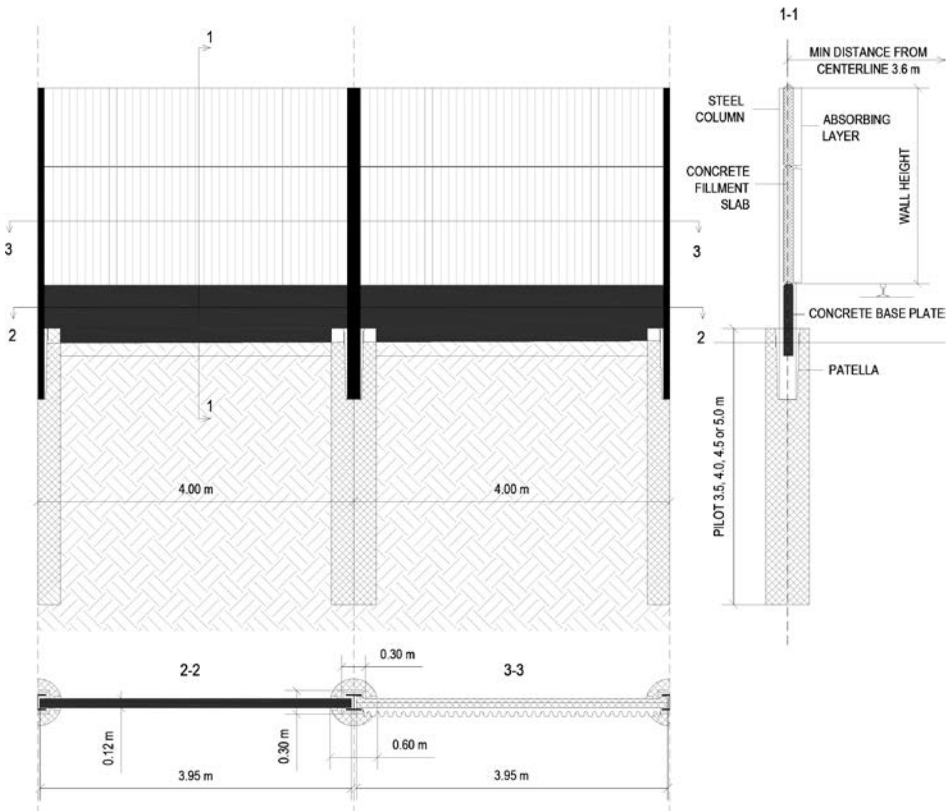

Figure 3 Elements of noise protection wall construction

5 Conclusions

Project of rail traffic noise protection described in this paper had few challenges that were gradually overcame by joint effort of Investor, project manager and designers. The biggest issue to the project designers was relatively late inclusion of noise protection project in the overall rail reconstruction project and lack of legislation to be followed in the design procedure. It is therefore important to emphasize that, for the future projects, noise protection walls design must be incorporated in early stages of the track (re)construction project, as they are an important part of track substructure and not a mere railway equipment.

Based on the existing trends in urbanization, increase in the amount of cargo transportation and environmental requirements, it can be said that the need for high quality railways in Croatia is in constant growth. Such expectations are based on the specifics of railways, long-term investment periods and the significant role of budget funding, especially in the area of infrastructure investments. Due to the economic situation, the planned construction of high-speed railway lines is now delayed and only rehabilitation of railway lines for speeds up to 100 km/h are planned. Nevertheless, this is the gap that needs to be fulfilled with quality noise protection structures construction legislation preparation.

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