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UNRELIABILITY OF INPUT PARAMETERS DURING THE RAILWAY NOISE BARRIERS DESIGN

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Abstract

The article shows noise measurement process caused by railway traffic on railway M604 Ostarije – Knin – Split, section Perusic – Gracac. Noise measurements were carried out for the validation of the noise barriers project on specified location. Considering the small number of trains which operate on specified location, continuous 24 hour measurements were carried out on each measurement position, where every train operation was recorded. Differences between measured noise levels and noise levels predicted in the project are given, where unreliability of input parameters during the railway noise barriers design is indicated. Finally, necessity of validating the predicted noise levels by the means of measurements is discussed.

Keywords: noise measurement, trains, project validation, unreliability of input parameters.

1 Introduction

According to the noise protection project, on railway M604 Ostarije – Knin – Split; from km 96+815 to the Gracac station (km 159+970) [1], noise barriers are needed due to noise emitted by passing trains. During the revision of the noise protection project the additional field noise measurements were required before the realization of the barriers themselves.

The goal of the required measurements was to determine noise levels on relevant measuring points where the noise barriers were set to build and then compare the noise level values obtained by measurements with those predicted in the project. Noise level predictions were performed by noise prediction software LimA ver.4.2.

2 Project data

2.1 General

Total length of the railway section where the noise barriers were set to build is 63.155m. The section begins just before Perusic station (km 96+815) and ends at Gracac station (km 159+970) [1]

Whole railway section is set on a flat terrain with maximum railway inclination of <6 ‰. [1]

Terrain configuration on the whole railway section is quite uniform and relatively simple for the acoustic modeling of the terrain including the 3D terrain model, digital model of objects and the ground surface type. Considering the emission noise levels of railway traffic, making of the reliable acoustic model was of the most importance.

2.2 Traffic data

Table 1 Number and type of trains with the share of daily and nightly traffic.

Train type		Number of trains	
		day	night
Cargo		8	5
Passenger	tilting	8	0
	dieselmotor	4	0
	classic	0	6*

*) 2 regular trains and 4 season trains (from 15.6 to 15.9)

Table 2 Average length and speed of the trains with the percentage of trains with disc brakes

Train type		Average length [m]	Speed [km/h]	Trains with disc brakes [%]
Cargo		300	80	0
Passenger	tilting	120	160	100
	dieselmotor	44	120	0
	classic	260	120	90

During the field noise measurements on the named section the actual number of passing trains was recorded. It was seen that the actual number of passing trains is almost twice as less than the number of trains from the project, partly respecting the fact that the noise protection project has been done with the possible increase of traffic in the years to come. Considering the mentioned facts it could be concluded that the train number parameter is quite unreliable during the acoustic modeling. However, if taken from appropriate traffic studies based on real projections it is quite reliable and this parameter affects the emission noise levels and therefore reflects the state of the traffic load projection itself. It is also noticed that the parameter of cargo trains length was not properly taken in consideration during the elaboration of the noise barriers design. The cargo train length varies regarding the type and quantity of cargo, operational time of day, etc. which affects the emission noise levels of railway traffic. Train speeds also differ from the input parameters of the project which were used for the acoustic modeling and the actual ones recorded in the field with speed limitations on the named section. Actual speeds are considerably lower then the ones in the project, with limitations from as much as 20km/h to 60km/h on certain segments. Thus, train speeds which varie regarding the segments of the section are definitely not reliable parameter during the acoustic modeling and it is not a good professional practice to define the train speed as a unique value on the whole railway section. The location of stations, actual speed limitations, etc. must be considered.

2.3 Selecting the appropriate calculation method

The selection of appropriate calculation method for noise levels emission and noise propagation was not chosen by the designer himself, but was set in the project's Terms of Reference. Nonetheless, this project displayed all the features of undefined entries regarding the calculation and noise protection design from traffic noise, mainly railway traffic. Three calculation methods for railway traffic noise prediction are used in Croatia:

- Schall 03 ("Richtlinie zur Berechnung der Schallimmissionen von Schienenwegen").
- RMR/SRM II ("Rekenen Meetvoorschrift Railverkeerslawaai '96"), poznatija kao "EU END Interim".
- ONRegel 305011.

The most important parameters which differ in these methods are:

- different categorization and the evaluation of wheel and rail roughness,
- different categorization and the evaluation of undercarriage and vehicle type,
- different categorization of engine noise,
- different processing of HVAC systems,
- different processing of aerodynamic noise,
- different processing of various acoustic effects characteristic for railway traffic (creaking, behavior on bridges, viaducts, tunnels, etc)
- possibility of obtaining the real emission noise levels for characteristic and actual railway construction in certain country.

According to the available data, comparison of the noise levels of equal railway traffic calculated using the different methods varies between 4 dB and 15 dB. Deviations in urban areas are less then those in the open landscape. The problem of standards implementation in noise prediction softwares is not considered here.

Therefore, traceability in the noise calculation methods can be ensured only with detailed legal procedures or mandatory recomendations of professional practice.

3 Noise level measurements

3.1 Requirements of the standard

According to the Terms of Reference and the valid standards, the noise level measurements had to be conducted in accordance with HRN DIN 45642:2005; Measurement of traffic noise (DIN 45642:2004).

Noise emission is characterized with average noise levels caused by railway traffic in the horizontal distance of 25m from the centre of the tracks at the flat terrain in the height of 3,5m above the upper edge of the tracks.

Emission noise level is obtained from the single event level measured.

The named standard differs following train types:

a passenger trains with cars entirely equipped with disc brakes
b passenger trains with at least one car equipped with the brakes on the wheel ring
c cargo trains
d trams, subways, urban railways

Considering the train types, measurements should include at least the following number of passing trains:

- train type a) 15
- train type b) 20
- train type c) 30
- train type d) 20

Measurement duration must include the shortest interval in which the noise level is 10 dB less then the maximum noise level during the train passing event.

During the measurement, background noise level must be at least 10 dB less then the maximum noise levels during the train passing event. [2]

3.2 Field measurements

The HRN DIN 45642:2005 standard requires the inclusion of at least 15 passenger trains passing during the measurement, while there are only 6 trains per day operating on the named section. Also, the standard requires the inclusion of at least 30 cargo trains passing, while there are only 16 trains per day on the day with the most frequent train passages.

With those limitations in mind and with the goal to gather as much high quality measurement data as possible, the noise level measurements where not completely carried out in the accor-

dance with the standard (regarding the number of passing trains). Instead, a continuous 24 hour measurements were carried out on each measuring position where every single train operation was recorded (total of 30 measuring points).
Measurements were conducted simultaneously on the 25m distance from the centre of the tracks (where it was possible) and in front of the residential buildings which are most threatened by the noise; on the 3,5m height. In the case of unfavorable terrain configuration the measurement was carried out only in front of the building.

3.3 Measurement results

Noise level measurements have shown that the dominant noise sources are cargo trains. Single event of the cargo train passing is louder and longer lasting then the passing of the tilting train. Below are given the equivalent noise level recordings of the cargo and tilting train passage on the same measuring position in the 25m distance from the centre of the track and in the height of 3,5m above the upper edge of the track.

Figure 1 Equivalent noise levels during the tilting train passage.

Measurement duration, T_M = 7 sec.
Maximum noise level, L_{max} = 76,5 dB(A).
Average noise level, L_m = 72,8 dB(A).
Single event level, L_{To} = 81 dB(A).

Figure 2 Equivalent noise levels during the cargo train passage.

Measurement duration, T_M = 17 sec.
Maximum noise level, L_{max} = 90,2 dB(A).
Average noise level, L_m = 86,2 dB(A).
Single event level, L_{To} = 99 dB(A).
In the following table the results of the noise level measurements are compared with the predicted values from the project.

Table 3 Comparison of the measured and predicted values.

Measuring point		Total noise level dB(A)		Background noise dB(A)		Number of trains		
		Day	Night	Day	Night	Cargo	Passenger (tilted)	Passenger (classic)
MM 1	Predicted	51,1	52,8	-	-	13	8	6/4
	Measured	54	58	48	39	11	3	2/0
MM 2	Predicted	55,7	57,4	-	-	13	8	6/4
	Measured	58	63	47	39	11	3	2/0
MM 3	Predicted	-	-	-	-	13	8	6/4
	Measured	57	61	44	37	11	3	2/0
MM 4	Predicted	53,9	55,7	-	-	13	8	6/4
	Measured	54	58	43	36	11	3	2/0
MM 5	Predicted	60	61,7	-	-	13	8	6/4
	Measured	60	64	47	40	16	4	2/0
MM 6	Predicted	54,5	56,2	-	-	13	8	6/4
	Measured	58	61	48	40	16	4	2/0
MM 7	Predicted	51,9	53,6	-	-	13	8	6/4
	Measured	57	62	51	43	14	2	2/0
MM 8	Predicted	58,0	59,7	-	-	13	8	6/4
	Measured	56	60	49	48	14	2	2/0
MM 9	Predicted	48,7	50,5	-	-	13	8	6/4
	Measured	62	57	62	54	10	4	2/0
MM 10	Predicted	50,8	52,5	-	-	13	8	6/4
	Measured	58	60	56	41	10	4	2/0
MM 11	Predicted	-	-	-	-	13	8	6/4
	Measured	55	62	39	36	11	4	2/0
MM 12	Predicted	51,3	53	-	-	13	8	6/4
	Measured	61	59	60	43	10	3	2/0
MM 13	Predicted	51	52,7	-	-	13	8	6/4
	Measured	54	57	52	40	10	3	2/0
MM 14	Predicted	50,8	52,5	-	-	13	8	6/4
	Measured	59	56	56	51	10	2	2/0
MM 15	Predicted	52,3	54,1	-	-	13	8	6/4
	Measured	64	57	64	56	7	4	2/0
MM 16	Predicted	49,6	51,3	-	-	13	8	6/4
	Measured	63	57	63	55	7	4	2/0
MM 17	Predicted	54,2	55,9	-	-	13	8	6/4
	Measured	49	51	47	41	7	4	2/0
MM 18	Predicted	50,2	51,9	-	-	13	8	6/4
	Measured	47	60	44	36	9	4	2/0
MM 19	Predicted	52,1	53,8	-	-	13	8	6/4
	Measured	55	63	52	38	10	4	2/0
MM 20	Predicted	49,2	50,9	-	-	13	8	6/4
	Measured	58	54	56	46	10	4	2/0
MM 21	Predicted	51,4	53,1	-	-	13	8	6/4
	Measured	57	62	53	52	8	5	2/0

MM 22	Predicted	49,8	51,5	-	-	13	8	6/4
	Measured	59	60	56	49	8	5	2/0
MM 23	Predicted	52,9	54,6	-	-	13	8	6/4
	Measured	52	55	49	44	8	4	2/0
MM 24	Predicted	53,1	54,8	-	-	13	8	6/4
	Measured	56	61	43	41	10	4	2/0
MM 25	Predicted	51,0	52,7	-	-	13	8	6/4
	Measured	53	58	50	50	10	4	2/0
MM 26	Predicted	49,7	51,4	-	-	13	8	6/4
	Measured	51	55	46	40	10	4	2/0
MM 27	Predicted	-	-	-	-	13	8	6/4
	Measured	46	51	42	43	8	4	2/0
MM 28	Predicted	56,3	58,0	-	-	13	8	6/4
	Measured	55	57	50	41	8	4	2/0
MM 29	Predicted	50,6	52,3	-	-	13	8	6/4
	Measured	49	55	43	44	8	4	2/0
MM 30	Predicted	55,0	56,7	-	-	13	8	6/4
	Measured	62	61	56	56	11	2	5/0

As the Table 3 shows, on a majority of the measuring points (26 out of 30) the recorded number of trains during the conducted measurements was less then a number of the trains taken as the input parameter for noise prediction in the project. Actual train speeds are lower during the measurement than those taken as the input parameter for noise prediction in the project. With lower actual speeds and number of trains that operates in the named section, lower noise levels than predicted ones were expected.

Despite the expectations, measured noise levels for the night time are higher then the predicted noise levels on a majority of the measuring points (all except MM 17 and MM 28). Only night time levels are considered here because regulation requirements are mort strict for this period of the day and because of the background noise influence which was definitely not dominant during the night- time measurements.

Background noise level with excluded noise from the passing trains is on the majority of the measuring points (23 out of 30) over 10 dB(A) lower than the total noise level with the passing trains included, while on 4 measuring points is from 5 to 10 dB(A) lower. Regarding this information, we can consider the noise levels obtained by measurements to be exclusively related to the noise emitted by passing trains and therefore the background noise level was not dominant.

4 Conclusion

With the lower traffic load and lower train speeds noticed during the measurements than those taken as the input parameters for the noise prediction, measured noise levels were higher than the predicted ones on the majority of the measuring points (28 out of 30). It is obvious that the predicted noise levels do not correspond to the actual conditions in the field.
If the noise barriers were to be constructed based on the project, the noise levels would be in accordance with the permitted noise levels by national standards on the majority (28 out of 30) of the measuring points.
However, based on the results obtained by noise measurements and with the expected noise level reduction due to barriers, on the majority of the measuring points (27 out of 30) the noise barriers wouldn't reduce the noise to the satisfactory values.
Considering the comparison of the predicted and measured values of the noise levels, the validation of the predicted noise levels is of the most importance. In this case, even the fewer train passes than the predicted number caused higher noise levels than the predicted ones. Therefore, the construction of the noise barriers according to the initial project wouldn't fulfill its function and would prove to be uneconomical. Al further actions in terms of sound insulation improvement would be time consuming, expensive and complicated.
In the whole process of noise barrier design it is important to implement control field measurements and import another step in the noise prediction process where the acoustic model would be updated and validated based on the conducted measurement data. Validation of the predicted noise levels is a necessity and it should be carried out regularly and not occasionally as a requirement of the project auditors. Thus, the credibility and accuracy of the predicted noise values would definitely increase, also as the functionality and the feasibility of the noise barriers themselves.
For easier comparison between measured and predicted noise levels we realize the necessity to determine one calculation method which would be implemented in professional engineering practice of railway noise barriers design and also to further determine the evaluation of the measured levels in accordance with demands of HRN EN ISO 1996-2.

References

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[2] DIN 45642:2005: Mjerenje buke prometa.