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COMPARISON OF SOME CALCULATION MODELS FOR RAILWAY NOISE PREDICTION

Summary. The noise pollutes the environment. The paper deals with comparison of calculation prediction methods of railway noise in several countries of Europe and their comparison with measured value in the chosen railway section.

PORÓWNANIE METOD OBLICZENIOWYCH HAŁASU W TRANSPORCIE KOLEJOWYM

Streszczenie. Hałas kolejowy negatywnie oddziałuje na środowisko naturalne. Artykuł przedstawia analizę obliczeniowych metod predykcji hałasu kolejowego stosowanych w wybranych krajach Europy. Otrzymane z wykorzystaniem tych metod wyniki porównano z wartościami pomierzonymi na konkretnym odcinku linii kolejowej.

1. INTRODUCTION

Noise pollution is an increasing problem within the European countries. Sources of the noise are: traffic, industrial manufacture, civil noise and other activities, but the transport noise has the main contribution to the noise environmental stress.

The paper compares measured values of the railway noise with calculated values according the prediction models Metodické pokyny SR, Shall 03, Nordic Train and Calculation method by the Hungarian standard MSZ – 07 – 2904 – 1990.

2. MEASURED VALUES OF THE RAILWAY NOISE

On the Žilina - Čadca welded straight railway track, some measurements were made at the village Brodno in 7,5 m distance from the nearest track axle and 1,5 m above the surface. The energy equivalent sound pressure levels from the measurements are listed in the tab.1.

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Table 1

Values of the measured noise levels

No. of measuring	$L_{Aeq,i}$ (dB)	The basic noise level L95 (dB)	speed of the train (km/h)	Duration of the interval t_i (s)
1	95,6	51	80	43
2	81,5	55,5	100	21
3	80,8	52,5	100	21
4	87,2	48,5	100	24

The energy equivalent sound pressure level L_{Aeq} is calculated with the formula:

$$L_{Aeq} = 10.\log\left(\frac{1}{\sum_{i=1}^{n} t_i}\cdot\sum_{i=1}^{n} t_i \cdot 10^{0,1 \cdot L_i}\right), \quad \text{(dB)} \qquad (1)$$

where:

t_i - measurement time interval (s),

n - number of level intervals,

L_i - average sound pressure level in the ith interval, (dB).

$$L_{Aeq,1h} = 10.\log\left(\frac{1}{3600}\cdot\left(43.10^{9,56} + 21.10^{8,15} + 21.10^{8,08} + 24.10^{8,72} + 3494.10^{5,19}\right)\right) = \mathbf{76{,}85\ dB}$$

3. RAILWAY NOISE CALCULATION ACCORDING THE PARTICULAR PREDICTION METHODS

3.1. Methodical Direction Used in the Slovak Republic [1]

In the Slovak Republic the methodical direction „Metodické pokyny pre výpočet hladín hluku od dopravy“ [2], Príloha 2 is used for calculation of the energy equivalent of the railway noise level. The input parameters are the graphic and traffic data.

The Emission Noise Level is calculated for the reference distance of *7,5 m* from the nearest track axle and altitude of *1,5 m* above the railway head.

The emission level Y is calculated with the formula:

$$Y = 40 + 10 \cdot \log X \qquad \text{(dB(A))} \qquad (2)$$

The X is calculated from the formula:

$$X = 140 \cdot F_4 \cdot F_5 \cdot F_6 \cdot m, \qquad (3)$$

where:

F_4 - factor of the traction influence,

F_5 - factor of the influence of the train speed in the measurement section,

F_6 - factor of the average number of the vehicles (wagons and locomotives) in the train

m - average number of passage trains during 1 hour.

According to the various reference distances of the compared prediction methods (7,5m and 25 m), it is necessary for the analysis to consider the absorption of the noise due to the distance, that is 7 dB has to be added or subtracted, respectively.

3.2. Schall 03 /DIN 18005/ [2], [3]

The German Federal Railroad Deutsche Bahn A.G. developed *Schall 03*, amend in august 1990, for the railway transport. The calculated sound level is L_{eq} for the day (6:00 to 22:00) and night (22:00 to 6:00).

The emission level is calculated from the traffic data for a reference distance of ***25 m*** from the nearest track axle and altitude of ***3,5 m*** above the railway head.

Trains of a similar type, speed and disk brakes percentages are added to determine the emission level of this particular class of train. The emission levels of all groups of trains are added energetically to form the overall emission level for day and night.

The emission level $L_{m,E}$ is calculated with the formula:

$$L_{m,E} = 10 \cdot log \sum 10^{(0.1(51 + D_{Fz} + D_D + D_L + D_S)} + D_{Tt} + D_{Br} + D_{LC} + D_{Ra} \quad \text{(dB)} \qquad (4)$$

where:

51 dB is the basic noise level of one train,

D_{Fz}, D_D, D_L and D_S are corrections corresponding to the particular train,

D_{Tt}, D_{Br}, D_{LC}, D_{Ra} are corrections corresponding to the track type,

The values of the corrections are calculated (or set) for the German condition.

3.3. Nordic Train [3]

The Nordic Rail Traffic Noise Prediction Method applies for all countries in Scandinavia. It is the only method known considering the L_{Aeq} and the L_{max} from trains. The reference noise level describes the emission by all trains during a 24-hour period. The reference level is valid for a train on infinitely long, straight track with continuously welded rails.

The emission noise level for the L_{Aeq} calculation is:

$$L_{Aeq} = 50 + 10 \cdot log\left(\frac{l_{24}}{1000}\right) - 10 \cdot log\left(\frac{a}{100}\right) + 23,5 \cdot log\left(\frac{V}{80}\right), \quad \text{(dB)} \qquad (5)$$

where:

a – perpendicular distance from the track centre line to the prediction position, (m),

l_{24} – total train length of all passing trains, (m),

V – speed of the train, (km/h)

3.4. Hungarian Prediction Method [4]

Hungarian prediction method is calculated by the standard MSZ – 07 – 2904 – 1990.

The emission level is calculated from the traffic data for a reference distance of ***25 m*** from the nearest track axle and altitude of ***0,5 m*** above the railway head for the day (6:00 to 22:00) and night (22:00 to 6:00).

The emission noise level for the L_{Aeq} calculation is:

$$L_{Aeq} = L_{Oi} + 10 \cdot \log Q_i + 10 \cdot \log \frac{l_i}{l_{Oi}} + 20 \cdot \log \frac{V_i}{V_{Oi}} \quad \text{(dB)} \qquad (6)$$

where:

L_{Oi} - noise emission level by the train, (dB),
Q_i - average number of passage trains during 1 hour
l_i - train length, (m),
l_{Oi} - reference train length, (m),
V_i - speed of the passing train, (km/h),
V_{oi} - reference speed of the train, (km/h).

4. CONCLUSIONS

The accuracy of the calculation models depends on correct identification of the parameters, which influence the railway noise level, of their number and correct identification of their influence.

The particular noise prediction methods can be difficult to compare as they differ in:

- measured distance,
- reference time period,
- input parameters.

The only parameter, which is the common for all mentioned calculation methods, is the parameter of the speed. The comparison of the calculation methods by the speed is in the *Fig. 1.*

Increasing speed increases the railways noise value. The relative increase of the noise is by the majority mentioned calculation methods, the same, about 12 dB (only Nordic Train method has 14 dB). The emission noise level is by the Methodical Direction SR lover than by the Schall 03, but at lover and higher speeds (40km/h a 160 km/h) are just the same. The highest emission noise level is calculated by the Nordic Train method and the lowest by the Hungarian calculation method.

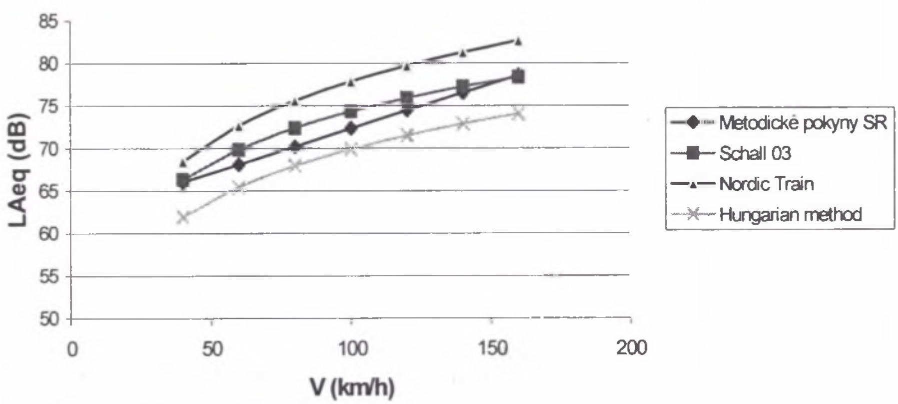

Fig. 1. Comparison of the calculation methods
Rys. 1. Porównanie metod obliczeniowych

Results of the calculations according to the prediction methods and the difference of the measured value are given in the *Tab. 2.*

Table 2

Comparison of the calculated values and measured values of the railway noise

Prediction Methods	L_{Aeq} (dB)	difference of the measured value $L_{Aeq} = 76,9\ dB$
Methodical Direction SR	69,5	7,4 dB
Schall 03	70,9	6 dB
NORDIC TRAIN	76,9	0 dB
Hungarian prediction method	68,2	8,7 dB

Schall 03 makes provision for more details, which influence the calculated result but it is specified for Deutche Bahn. The calculated value by Nordic Train is the closest to the measured value form the others calculated values.

The measured results are considered to be the most exact although they are sensitive on unexpected events. Calculated results have average and statistical character, because the input parameters have average character. But the calculated method should be the most suitable for a certain country and certain traffic and approach to the measured values.

References

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