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Determination of Insertion Loss of Acoustic Barriers under Specific Conditions

Aleksandras Jagniatinskis^a, Boris Fiks^{a,*}, Marius Mickaitis^b

^a*Scientific Institute of Thermal Insulation, Vilnius Gediminas Technical University, Lithuania*

^b*Faculty of Civil Engineering, Vilnius Gediminas Technical University, Lithuania*

Abstract

The World Health Organization the noise from road traffic composes as a main contribution in the total environment noise. In suburbia areas near the highways road traffic produce especial high noise levels. The acoustic barriers along the roads are designed to reduce this noise impact in protected against noise areas. The effectiveness of such barriers is expressed by “insertion loss” descriptor and determined from an in-situ measurement according to ISO 10847 standard that cover only typical in-situ situations. But there are some cases when the additional efforts are needed for adequate/realistic insertion loss determination. When, local connection road is constructed inside the barrier protected area and noise from this road mask the sound penetrating through the barrier from the highway. In such case insertion loss cannot be measured directly by standard procedure. In such specific conditions the application of provisions of the ISO 1996 series standards can be adopted to highway’s noise extraction from total environmental noise measured inside protected area. The appropriate methodological solutions of discussed problems with the practical results of in-situ experimental measurements are presented.

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* Corresponding author.

E-mail address: boris.fiks@vgtu.lt

1. Introduction

Road traffic noise by the World Health Organization (WHO) [1] contributes mainly to the environmental noise pollution. One of the noise abatement measures is to build across the roads (highways) noise barriers that separate roads from protected areas of environment. Such barriers design for various environmental conditions is a complicated task [2, 3] especially when acoustic effectiveness together with construction cost are considered [4]. The problems concerned to the determination of effectiveness of various form of noise barriers are studied also in [5–7] applying in situ measurements [5] as well as the modeling technique [6, 7]. The acoustic effectiveness of noise barriers is described using “insertion loss” descriptor D_{IL} and determined from an in-situ measurement according to the ISO 10847 standard [8]. By standardized method barrier insertion loss is calculated as a difference between simultaneously measured noise levels on reference microphone position and interested environmental site point with following subtraction of so-called environmental correction. The last one is analogously determined as a difference or just for this site before the barrier is erected or in the similar environmental site without barrier.

The usage provisions of ISO 10847 sometimes are complicated when in the interested site point exist a relatively high background (or extraneous) noise level. Such level may be caused by common noise situation in the protected area (especially when the distance to the noise barrier is relatively large) or when the local connection road is constructed inside the barrier protected area. In last situation the noise penetrating through the barrier is an object for measurements. But, it is evident that noise from this road masks in some time intervals sound penetrating through the barrier and insertion loss cannot be determined directly by standard procedure.

In such specific conditions the application of provisions of the ISO 1996 series standards [9, 10] can be adopted to the highway’s noise extraction from total environmental noise measured inside protected area. In presented paper the case study of connection road constructed inside the barrier protected area is studied. Correspondingly the disturbing noise generated by traffic from local road, what make problems for barrier insertion loss determination, is focused in this paper only.

2. Environmental situation description

View of the case study site is presented in Fig. 1.



Fig. 1. Local connection road in the noise protected area and reference microphone point above the barrier (a); interested site point with 4 m height microphone (b).

In presented experimental site the height of the barrier is 5 m and the investigated point in protected area is placed 30 m from the barrier. For comparison in second investigated analogous site the height of the barrier was 6 m and the investigated point in protected area is placed at the 20 m distance from the barrier.

The predictable traffic flow on considered highway (before highway reconstruction) A5 Kaunas–Marijampolė 17 km at day time under the project of reconstruction was 600 vehicles/h and about 35 % of heavy transport. The preliminary measurement time interval for every considered environment point of interest was chosen according to recommendations presented in standards [8, 10] where the minimum of 30 vehicle passing bys for every category must be considered. For purpose of experimental measurements to collect more statistics about highway traffic noise at least 100 heavy vehicle passing bys was chosen. For points of site 1 when the measurements was stopped the 105 heavy and 160 light vehicle passing bys were registered. The appropriate measurement time interval was 26 min. For more informative description of noise generated by highway traffic the appropriate histogram of noise levels, $L_{Aeq,100ms}$ registered on microphone placed above barrier (see Fig. 1a) is presented in Fig. 2.

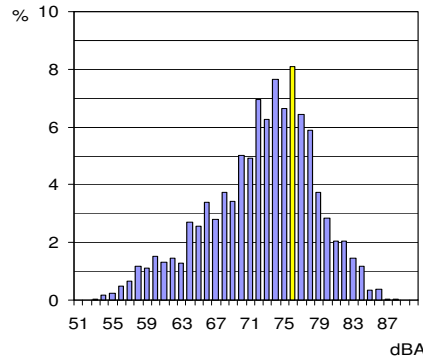


Fig. 2. Distribution histogram of noise levels registered above barrier (yellow bar correspond to the equivalent level of 76 dBA).

The appropriate noise situation registered on the microphone placed in the environmental site point (see Fig. 1b) is shown in Figs 3 and 4 where the overall time history of the noise levels as well as the undesirable vehicle passing bys in local road are presented.

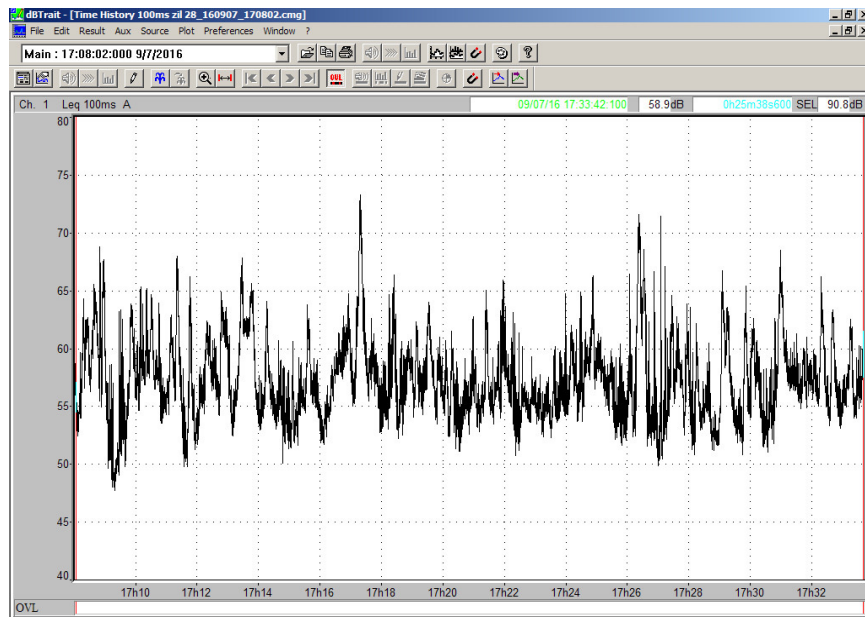


Fig. 3. Noise time history in the investigated site: whole measurement interval.

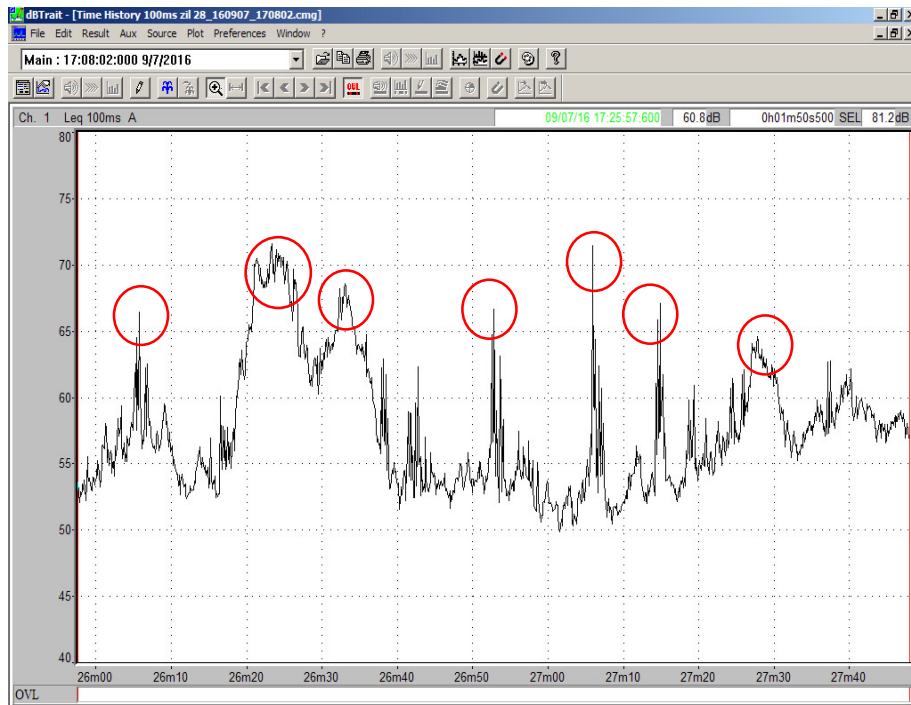


Fig. 4. Noise time history in the investigated site: 2 min interval with marked vehicle passing bys occurred in the local connection road.

3. Insertion loss determination

In the whole measurement time interval in the first measurement site described in Section 1 was registered 45 vehicle passing bys. The summarized duration of these passing bys was about 7 min. The insertion loss spectrum was calculated for the 1-st measurement site. It may be achieved when the appropriate time intervals of occurred passing bys in the local road are eliminated from the time histories on reference and site microphones. Measured spectral data needed for insertion loss determination are presented in Fig. 5.

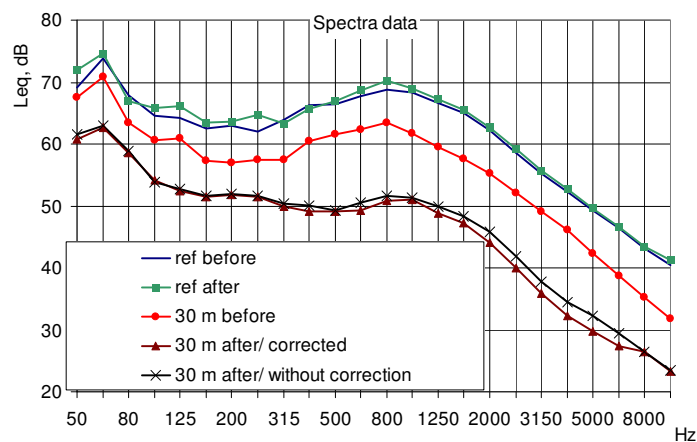


Fig. 5. Spectral data for insertion loss determination for point placed 30 m from barrier.

In Fig. 5 are presented measured spectra for the reference point (microphone height 6.5 m and placed near the road on barrier level). Situation “before” in Fig. 4 means that these measurements are performed in the similar to the investigated site points without the barrier. Situation “after” in Fig. 5 means that measurements are performed in the site with barrier. Presented results shows that corrected spectrum (after passing by elimination) have lower values than initial spectrum. The resultant insertion loss is presented in Fig. 6.

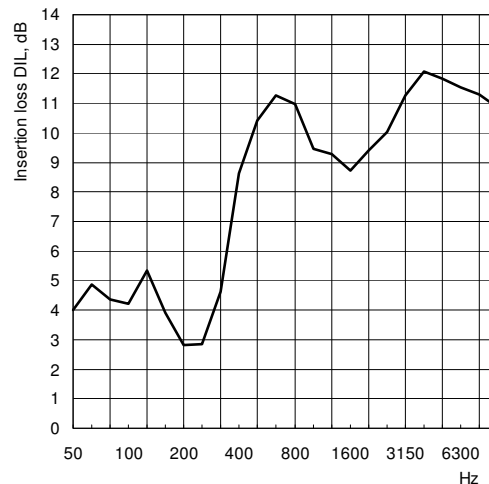


Fig. 6. Insertion loss spectrum for site 1 with A-weighted value of $D_{IL,A} = 10.6$ dBA.

For comparison an alternative approach for A-weighted insertion loss determination, based on the vehicle sound exposure levels determination [11], is presented. Using this method the noise generated from vehicle passing by per local road is treated as special noise and must be eliminated by energy principle from the total noise. Obtained residual noise level present the noise penetrating through barrier and is used for barrier insertion loss determination. The numerical results of calculations are presented in Table 1.

Table 1. Determined A-weighted data in site points for insertion loss assessment.

Site point distance from barrier	Total levels, dBA		Determined levels, dBA			
	At the site point	At the reference point	Special from connected road	Residual from highway	Environment correction	Barrier insertion loss
1: 30 m	58.9	76.0	55.4	56.3	-9.1	10.6
2: 20 m	61.5	75.4	60.4	55.0	-6.9	13.5

4. Conclusions

The principles for barriers insertion loss determination in the special environment conditions when the noise generated from local road traffic mask the “useful” noise penetrating through the barrier are described.

Was shown a possibility to determine the A-weighted insertion loss of barrier using two approaches: first based on the time intervals elimination, where the impedimental noise events occurs and second one is based on the sound exposure level of every vehicle passing by measurement with following their elimination from total environmental level measured in the interested environment point.

Experimental data shows that these two approaches give practically identical results for A-weighted insertion loss determinations. For 5 m barrier designed in site 1 for point placed 20 m from the barrier the insertion loss was found equal to 10.8 dBA, while when the elimination procedure of undesirable passing by events are not carried out the

value of barrier insertion loss was equal to 8.0 dBA. Analogously at site 2 for 6 m barrier the corrected insertion loss of 13.5 dBA for point placed 20 m from the barrier was obtained.

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