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Insertion Loss Analysis of the Acoustic Panels with Composite Construction

In order to reduce noise pollution, under European legislation in our country need to align, a special attention has the tests carried out on acoustic panels. The most eloquent attempts, defining traffic noise attenuation are tests that can determine the insertion loss of an acoustic screen. In this paper, it briefly shows the method of determining the insertion loss in octave bands and some real results in the case of acoustic panel in a composite construction.

Keywords: *acoustic panels, insertion loss, composite*

1. Introduction

Worldwide, acoustic panels are mainly used to attenuation of traffic noise, which influences current human activities. Usually, they are a necessity to limit noise limit residential buildings in order to comply with the maximum permitted levels. These acoustic panels can be installed near high traffic road ways for different categories of vehicles and near railways.

These panels can be made of various materials such as wood, PVC, concrete, metal, etc.

Height and composition of these acoustic panels can be established and designed according to the sound spectrum of traffic, which is determined by measurements of the stock of noise from road or rail. It is also very important to know the distance from the noise source in this case is traffic noise at the receiver. Receiver noise level can be reduced by blocking the line of sight between the vehicle and the receiver. The existence of a high building heights behind the barrier can significantly reduce the insertion loss performed by acoustic panels [1].

Over the last decades, to reduce traffic noise in Europe, regulations restricting noise emission by vehicles have been continuously updated. However, the reduction of traffic noise levels during this period was not significant [2-3]. In fact, reducing noise from engine was partially masked by increasing noise from tire-road contact. As a result, the tire noise is mostly running at speeds above 40 km / h for cars and 70 km / h for trucks [4]. Therefore, in response to the 1982 work of Sandberg [5] can provide arguments to the effect that tire rolling noise is likely limiting factor in reducing noise of vehicles.

Until now, from theoretical point of view, there are a multitude of analytical and finite element methods and specialized software to characterize the efficacy of acoustic panels. Most had at the Moreland-Musa method [6] which takes into account the geometry of the panel acoustic diffraction phenomenon at the top of the panel.

In the design phase of acoustic panels, must take into account the mechanical characteristics and the stability of acoustic panels, so as to resist dynamic loads due to from wind load, dynamic pressure due to vehicle safety in case of collision, dynamic loads due to snow cleaning - requirements that are in accordance with SR EN 1794-1 [7].

2. In situ determination of insertion loss of acoustic panels

To be closer to the real values due to noise reduction using acoustic panels were implemented several methods for measuring effective attenuation capacity acoustical panels, including the method described in standard ISO 10847 [8].

This International Standard specifies a method for determining the insertion loss of the anti-noise screens used outside, for shielding of noise sources of different types. It specifies detailed procedures for in situ measurement of the insertion loss of the screen, containing microphone positions, conditions for acoustic media source and measurement locations.

Insertion loss determination of acoustical panels can be made as follows:

- from level difference before and after installation of anti-noise screens and when this is not possible because the screen has been installed;
- using an indirect method to estimate the sound pressure level before installing the screen by measuring in another place that was considered equivalent.

To define the acoustic parameters, according to the same standard [8], were considered the following notations:

- Equivalent continuous sound pressure level

$$L_{peq,T} = 10\lg\left[\frac{1}{T}\int_{t_1}^{t_2}\frac{p^2(t)}{p_0^2}dt\right] \ [dB], \quad (1)$$

where:

t_1 and t_2 are the times corresponding to the beginning and the end of the measurement period $(T = t_2 - t_1)$;

$p(t)$ is an instantaneous sound pressure;

p_0 is a reference sound pressure (20 μPa).

- A-weighted sound exposure level

$$L_{AE} = 10\lg\left[\frac{1}{T_0}\int_{t_1}^{t_2}\frac{p_A^2(t)}{p_0^2}dt\right] \quad [dB], \tag{2}$$

where:

$p_A(t)$ is a instantaneous weighted sound pressure;

$(t_2 - t_1)$ is a specific time interval, long enough to cover all significant sounds of an indicated event;

p_0 is the reference sound pressure (20 μPa);

T_0 is the time reference (1s).

Screen insertion loss determination can be made as [8]:

a) The direct method when the insertion loss is obtained when the acoustic panel sound pressure levels can be measured directly in both cases "before" and "after".

$$D_{IL} = \left(L_{ref,A} - L_{ref,B}\right) - \left(L_{r,A} - L_{r,B}\right), \tag{3}$$

where:

$L_{ref,B}$, $L_{r,B}$ is the sound pressure level "before" in reference position of the receiver position;

$L_{ref,A}$, $L_{r,A}$ is the sound pressure level "after", in reference position of the receiver position;

b) Indirect measurement method when sound pressure level "before" was not measured and carried out measurements of sound pressure level "before" and "after" in a place equivalent. This equivalence, must take into account the profile of the terrain, soil conditions and the noise source.

$$\Delta L_B = L_{ref,B} - \left(L_{r,B} - C_r\right), \tag{4}$$

$$\Delta L_A = L_{ref,A} - \left(L_{r,A} - C_r'\right). \tag{5}$$

unde:

$L_{ref,B}$, $L_{r,B}$ is the sound pressure level "before" in reference position or the receiver position (elsewhere);

$L_{ref,A}$, $L_{r,A}$ is the sound pressure level "after", in reference position or the receiver position;

C_r and C_r' are correction factors for type receiver position ($C_r = 0\ dB$ for "semi-free field" and $C_r' = 6\ dB$ for "reflective surfaces")

Thus, the insertion loss of the screen, as indirectly measured, are:

$$D_{IL}' = \Delta L_A - \Delta L_B \,. \tag{5}$$

3. Experimental results and conclusions

Next, in the Figure 1, is given a measurement of the real situation of composite acoustic panel, consisting of concrete, mineral wool and a layer of wood chips. It has a length of 10.2 m and a height of 3.5 m.

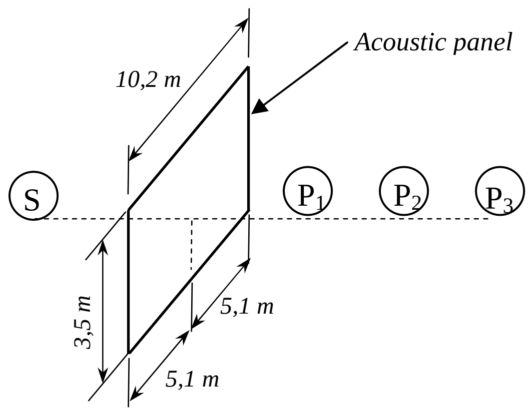

Figure 1. The locations of measurement points

Notations used in Figure 1, are the following:

- **S** – The position of the source - OmniPower (2.5 m before the panel at the height of 1.5 m)
- **P_1** – The measurement point 1 (at a distance of 2 m, to the acoustic panel, on 1.5 m height)
- **P_2** – The measurement point 2 (at a distance of 4 m, to the acoustic panel, on 1.5 m height)
- **P_3** – Measuring point 3 (at a distance of 6 m from the acoustic panel, on 1.5 m height)

Noise measurement in points **S**, **P_1**, **P_2**, **P_3** was performed with a Brüel & Kjær 2250 sound level meter. To generate noise was used OmniPower sound source, type 4296 Brüel & Kjær. The background noise level, measured on an interval of 3 min was 44.6 dB (A)

The difference levels (the insertion loss) between the source **S** and the noise level of the noise measured at the points $\mathbf{P_1}$, $\mathbf{P_2}$, $\mathbf{P_3}$ are shown in Table 1, the one-third octave bands. For simplicity, insertion losses are denoted DL1, DL1 and DL3.

Table 1.

Frequency [Hz]	Leq [dB(A)]				$\mathbf{DL_1}$	$\mathbf{DL_2}$	$\mathbf{DL_3}$
	S	$\mathbf{P_1}$	$\mathbf{P_2}$	$\mathbf{P_3}$			
50	58.48	47.41	48.25	51.2	11.07	10.23	7.28
63	60.93	46.98	47.79	52.95	13.95	13.14	7.98
80	74.44	51.88	57.68	58.96	22.56	16.76	15.48
100	83.37	59.58	58.66	61.14	23.79	24.71	22.23
125	87.86	63.18	64.88	61.37	24.68	22.98	26.49
160	94.66	69.38	69.93	67.03	25.28	24.73	27.63
200	96.06	69.16	67.58	66.89	26.9	28.48	29.17
250	91	68.59	66.07	66.96	22.41	24.93	24.04
315	95.97	65.36	64.77	65.91	30.61	31.2	30.06
400	93.88	61.82	62.36	61.78	32.06	31.52	32.1
500	95.97	67.42	60.48	64.11	28.55	35.49	31.86
630	91.69	65.6	61.71	60.73	26.09	29.98	30.96
800	91.84	62.59	60.66	62.56	29.25	31.18	29.28
1000	90.68	59.85	60.65	61.57	30.83	30.03	29.11
1250	88.64	58.83	57.78	57.58	29.81	30.86	31.06
1600	89.77	60.72	60.69	61.61	29.05	29.08	28.16
2000	85.49	60.37	59.54	60.1	25.12	25.95	25.39
2500	84.67	60.91	58.95	58.78	23.76	25.72	25.89
3150	84.79	58.69	57.29	57.8	26.1	27.5	26.99
4000	82.59	51.87	50.77	52.57	30.72	31.82	30.02
5000	67.96	39.39	37.77	40.77	28.57	30.19	27.19
6300	68.58	36.29	37.2	38.19	32.29	31.38	30.39
8000	68.13	35.9	35.52	36.43	32.23	32.61	31.7
10000	59.06	29.36	29.42	35.8	29.7	29.64	23.26
12500	44.2	27.42	27.35	32.79	16.78	16.85	11.41
16000	37.32	24.96	25.07	30.16	12.36	12.25	7.16
20000	33.34	20.95	21.52	26.95	12.39	11.82	6.39

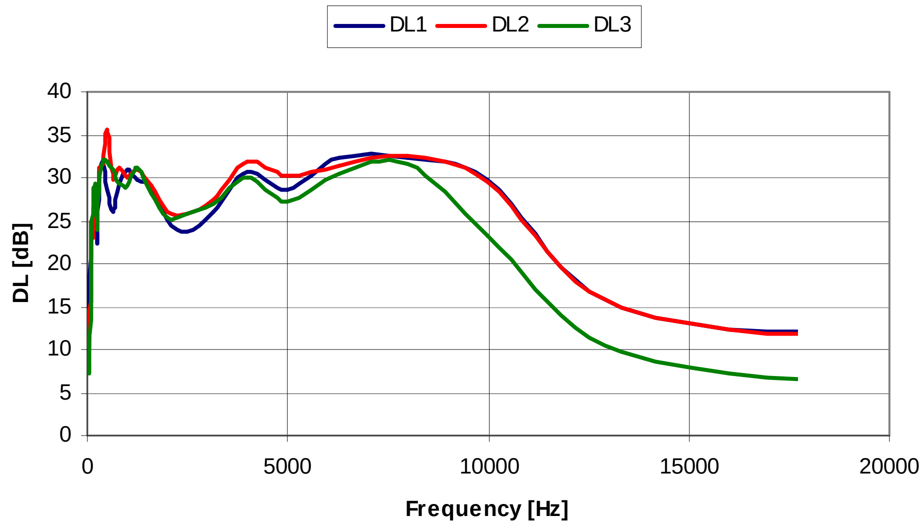

Figure 2. The insertion loss of acoustic panel
(DL1 – on 2m, DL2 – on 4m and DL3 on 6 m distance)

In Figure 2, we can observe the insertion loss of the panel to the position of the receiver, which is 2 m, 4 m and 6 m from the acoustic panel.

From this point of view, it is easily deduced that in the range 0-9000Hz, acoustic panel has a maximum efficiency, with an average reduction of 25 - 27 dB regardless of the position of the receiver. For higher values of frequency, marked differences appear which means that the increased distance between the receiver and acoustic panel, panel efficiency decreases.

References

[1] Walerian E., Janczur R., Czechowicz M., *The effectiveness of screens in an urban area*, *Applied Acoustics*, 58, 153–172, 1999.

[2] Kragh J., *Nordic prediction for road traffic noise. New basic input values due to the tightening of vehicle noise limits?*, Danish Acoustical Institute Report LI 971/91, Lyngby, Danmark, 1991.

[3] Sandberg U., *Noise emission of road vehicles - effects of regulation*, Status report of an I-INCE party In Proceedings of inter.noise 93, Leuven, Belgium, 1993.

[4] Sandberg U., *Tyre / road noise – Myths and realities,* Proceedings of Inter Noise 2001, The Hague, The Netherlands, 2001.

[5] Sandberg U., *Will tire / road noise limit future vehicle noise reductions ?*, Proceedings of Inter Noise 1982, San Francisco, USA, 1982.
[6] Enescu N., Vasile O., *The Decrease of Noise with Acoustics Barriers*, Romanian Journal of Acoustics and Vibration, Vol. IV, Number 2, December 2007, pp. 71-74, ISSN 1584-7284.
[7] SR EN 1794-1 – *Road traffic noise reducing devices – Non-acoustics performance. Part 1: Mechanical performance and stability requirements.*
[8] SR ISO 10847 - *Acoustics – In-situ determination of insertion loss of outdoors noise barriers of all types*.

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