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Phonic Attenuation due to Screen-Barriers

The technique of noise decreasing admits two basic approaches: an active approach and a passive one. In the frame of passive method one can count the employment of screen-barriers. In this paper we present some considerations on sound attenuation due to screen-barriers emphasizing the elements which influence it. The elucidation of these elements is made by measurements. The obtained results can be applied in every other practical situation concerning the protection against noise.

Keywords: *screen-barriers, noise attenuation*

1. Introduction

The problem of noise and vibration attenuation received in the last time an increased importance. This is due to the multiplication of noise sources having increasing powers. On the other hand, this problem received much attention because it has been proved that noise and vibration produce injurious effects on human's health, influencing adversely also the working efficiency. That is why noise control based on attenuation measures should be a special concern in all industrial domains. One remark that at international level there are established some limits for noise and vibration exposure. In Romania, the foundations of a large action concerning noise and vibration control have been set at an earlier stage [1].

In this paper we present some considerations about noise decreasing through passive methods, more specific noise attenuation due to screen-barriers. In this way, we identify the elements which influence it and also their effects. The elucidation of these issues has been made through measurements.

2. Noise sources

The environmental noise is generated from building sites, industrial equipments, sports activities on stadiums, markets activities, disco-clubs, road, rail and air traffic and so forth. The noise generated by these sources has noxious effects upon people life and activity, having specific sources, levels and characteristic spectra. Measurements should be performed in order to determine the characteristic levels and spectra and for identification of specific sources.

Within construction sites are working various machines and equipments such as excavators, bulldozers, cranes, concrete mixers, trucks, tractors, motor pumps and other devices. The noise generated by these ones originates in the mechanical, electromagnetical, aerodynamical and hydrostatical processes which arise during working regimes. Thus, the causes of noise appearance during the mentioned processes are the shock interaction of two or more bodies, the friction of interacting surfaces, the aerodynamical turbulences, the forced oscillations of the rigid bodies, the action of variable electromagnetic forces (especially at electrical operated groups), the vibration of road or membrane-shaped parts, pulsating pressure in hydrostatic operated devices.

Daily characteristic noise levels on building sites are situated between 85-110 dB for frequencies ranging between 30-300 Hz. Also, the presence in the traffic of a large number of trams, trucks, buses, minibuses, motor-cycles, tractors, trains and airplanes contributes to an increased noise level. The deteriorated state and the nature of the road superstructure favored high value of the noise level produced by different types of vehicles, in term of speed.

From measurements performed in 119 measured points from the road and rail traffic from Timişoara City, in 95 of them (79.83%) the equivalent noise level exceeds the maximum values established by STAS 10009-88 concerning "Urban acoustics". The registered overtaking ranged between 0.1-16.1 dB. The traffic intensity registered values from 9 veh/h to 2681 veh/h and the vehicle speed was found to be between 50-60 km/h [5], [6].

The noise level of 50 dB admitted at 2 m distance from the building wall was in general exceeded with 1.3-32.9 dB.

The noise level generated by trains measured at the railway zone limit exceeds the admissible value with 2.2-12.7 dB. At Timişoara Airport, the noise exceeds the admissible value with 7 dB [5]. The increase of the noise is primarily due to the vehicles, trains and airplanes circulation, to the change of direction of displacement, to vehicles passing over the tram rails, to the acceleration and breaking.

During the displacement of the vehicles on corridor streets, the increased noise level is produced also by the superposition of the reflected waves on the direct ones. The high degree of technical deterioration of some vehicles is an important factor that increases the noise level produced by the road traffic.

This situation related to high noise levels is present in the most urban zones. Because in the most of the measured points the admissible limits of the noise level are exceeded, it is necessary to decrease this noise weather by active or passive methods.

3. Noise attenuation due to screen-barriers

In order to reduce the noise in urban zones such as Timişoara-City, some noise decreasing measures have been implemented. In this way, on many streets the superstructure of the runways was improved. Many crossings were modernized and semaphores were installed. One-way traffic was imposed for some road thoroughfares, the speed of the vehicles was limited and on many streets were installed physical speed-limiters. It was eliminated the presence in traffic of heavy trucks in the central area of the City. In some areas, it was allowed the access only for certain categories of vehicles. In the N-E of the City was activated the ring-road which re-direct the heavy traffic in this direction.

The effects of the implementation of these measures intended to noise reduction were evaluated through new measurements.

Analyzing the data of these measurements one can conclude that by implementing the methods for noise reduction, it was obtained indeed a decrease of the noise levels but the admissible limits established by STAS 10009-88 are still exceeded. In this case, other acoustical arrangements on the thoroughfares are needed to be established and implemented in order to diminish further the noise generated by transportation means.

An attenuation of the noise level in the urban environment can be obtained by increasing the distance between the industrial areas and the runway and by creation of protection areas (green zones). In the cases when it is not possible to use these measures, artificial screen-barriers must be resorted to.

The screens represent the interposed obstacles between the noise source and receiver with the aim at obtaining a significant reduction of the noise level at receiver. The screens could be natural (skirts of trees, diverse elevations of ground and others) or artificial (walls, floors and others)

At an interposition of the screen between the source and receiver, the acoustic field is disturbed and new phenomena appear which are known under the name of diffraction.

The study of the acoustic field in the presence of an acoustic screen is highly complicated because it depends on a large number of factors and parameters. One of the main aspects consists in the investigation of the acoustical energy at receiver in the opposite side of the sound source.

The efficiency of the screen depends on the relative positions of the source and receiver, on the source's directivity, on the screen dimensions, wave length, transparence of the screen, absorption of surfaces in the front of the screen, as well as on the positioning of the screen in free or closed space.

Screens are useful to noise localization at source for large machines and equipments, to the protection of the districts of houses against noise generated by road, rail or air transportation means or by industrial installations.

In this paper we investigate noise attenuation due to screen-barriers. Noise attenuation due to screen-barriers takes place due to appearance of the acousticshade. The calculus scheme of the noise propagation to the opposite side of the screen barrier is presented in figures 1 and 2.

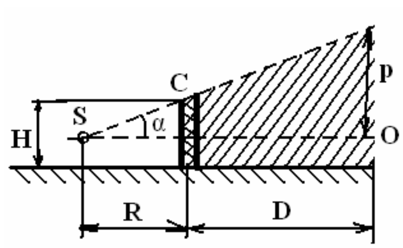

Figure 1. The calculus scheme of the noise propagation to the opposite side of the screen-barrier

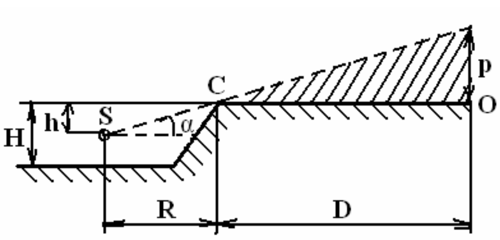

Figure 2. The calculus scheme of the noise propagation in the presence of a cutting slope

The noise attenuation due to screen-barriers can be calculated for different frequencies from the spectrum.

In the practice of screen-barriers engineering one can meet two cases: a) the noise source S and the receiver O behind the screen lie on the same horizontal line, and b) the noise source S and the receiver O lie at different levels comparing to the horizontal plane.

The attenuation due to screen-barriers depends on the height H, on the wave length λ of the disturbing sound, on the distances R between the barrier and the source and D between the barrier and noise receiver as well as on the difference of altitude between the source and receiver. If the source and the receiver are placed at the same altitude, the attenuation ΔL achieved using a screen having the length very large comparing to the sound wave length is [1]

$$\Delta L = 10\lg 20X \ , \tag{1}$$

where X has the expression

$$X = \frac{2\left\{R\sqrt{1+\left(\frac{H}{R}\right)^2}-1\right\}+D\left\{\sqrt{1+\left(\frac{H}{D}\right)^2}-1\right\}}{\lambda\left[1+\left(\frac{H}{D}\right)^2\right]}, \tag{2}$$

In the case when D>>R and R>>H, the expression (2) becomes

$$X \approx \frac{H^2}{\lambda R}, \tag{3}$$

and the attenuation can be determined using the diagram from [1], fig.4.1

The efficiency of the screens increases with their height and with the reduction of the distances between the screen and source or receiver. In the case of screens with less high, the effect obtained diminishes with the increasing of these distances.

The efficiency of the screen diminishes when the distances R and D exceed 100 meters. In these cases it must be taken into consideration the diffraction effect of the acoustic waves due to the limitations of the barrier, the attenuation produced by the soil, as well as the turbulence attenuation produce by the wind. The correction which must be applied depends on the speed of the wind and frequency, according to table 1 [1]

Table 1

Frequency band [Hz]	The speed of the wind [km/h]		
	3.3	6.6	13
37-75	0	0	1
76-150	0	0	3
151-300	0	1	6
301-600	0	2	8
601-1200	0	4	10
1201-2400	1	7	13
2401-4800	3	9	16
4801-9600	8	14	20

The expression (2) allows also the determination of the height of the screen when it is known the screen absorption and the distances R and D in order to obtain certain noise attenuation to receiver. Thus, for a screen having the absorption of 10 dB and R=D=8 m, λ=0.31 m, in order to obtain a noise attenuation of 33.9 dB at receiver, this must have 3.977 m height.

The noise attenuation obtained with the help of the protecting screens generally depends on the relative height between the noise source and the receiver. The determination of the attenuation in the point of observation P depending on the angle φ can be made using the diagram from [1], fig.4.2.

The effective height of the screen, in abscissa, is expressed in multiplies of the wave length of the disturbing noise.

In practical applications, it is indicated to specify the high of the noise source and when choosing the height of the screen it must be taken into account the position of the perturbing source.

Thus, in the case of the noise due to road traffic one must take account that the noise produced by the wheels is generated at the level of the pavement, the source of f the noise produced by the engine of the vehicle is located at 0.9-1.5 m height from the pavement, the source of the noise generated by the exhaust of gases in case of the truck's Diesel engine is located at 2.1-2.4 m height from the ground. In case of the noise produced by the rail traffic, the position of the noise source is located at the junctions between the rails**.**

4. Experimental investigations

In order to emphasize the phonic attenuation due to screen-barriers, some measurements were accomplished.

The measurements were performed for two types of screens. A first screen made of Plexiglas having dimensions 40x3x0.02 m was installed at 9.5 m distance from the axis of the first runway, next to a school. The effect of this screen on noise reduction can be observed in fig. 3 and 4, where are presented the frequency spectra obtained in a measurement point located at 7.5 m distance from the axis of the first runway at 2 m distance from the screen (fig.3), where L_{Aeq}=72.9 dB and in another measurement point located at 12 m behind the screen (fig.4), where L_{Aeq}=59.5 dB.

The traffic intensity in these situations was of 1914 aut/h and the traffic composition was as follows: buses 0.5%, trolleybuses 0.7%, microbuses 7.6%, cars 81.3%, trucks 9.7%, and motorcycles 0.2%.

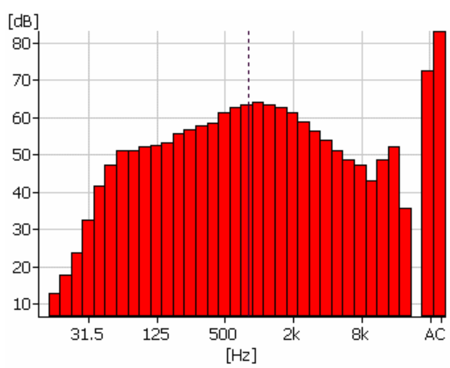

Figure 3. A-weighted frequency spectra at 2 m distance before the screen

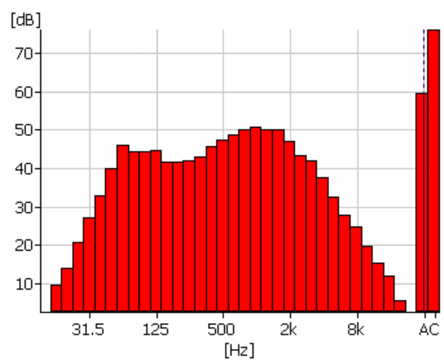

Figure 4. A-weighted frequency spectra at 12 m distance behind the screen

The second screen made of concrete having dimensions 100x2.5x0.12 m was installed at 3 m distance from the axis of the railway of the tram. The noise sources were represented by trams. The receiver was placed at 6 m distance from the screen. The effect of this screen upon noise reduction can be observed in figs.5 and 6, where are presented the values of the noise parameters and frequency spectra obtained at the noise source (fig.5), where L_{Aeq}=69.4 dB and at receiver (fig.6), where L_{Aeq}=59 dB.

Analyzing the values of the equivalent noise level L_{Aeq} measured at source and at receiver, as well as the frequency spectra diagrams from fig.3-6, one can be observed the noise attenuation due to screen-barriers.

A significant attenuation of the noise is emphasized, especially for high frequencies. Also, one can be observed that the efficiency of the screen-barriers depends on the relative position of the source and receiver, on the screen dimensions, on the wave length, acoustic transparency of the screen and others**.**

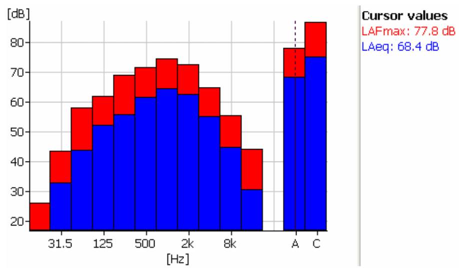

Figure 5. A-weighted frequency spectra at noise source

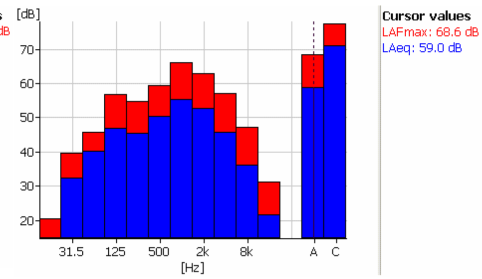

Figure 6. A-weighted frequency spectra at receiver

4. Conclusions

After performing the investigations described in the paper, it was possible to evaluate the noise attenuation due to screen-barriers. The screen-barriers can be used for acoustical arrangement of the urban environment. The acoustical screen-barriers lead to a diminution of the noise pollution and contribute to a lower percentage of disturbed people.

Once the efficiency of the methods intended to noise attenuation through screen-barriers was proved, one can apply such methods in every practical situation concerning traffic and industrial noise in urban environment.

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