TECHNICAL UNIVERSITY OF CLUJ-NAPOCA

ACTA TECHNICA NAPOCENSIS

Series: Applied Mathematics, Mechanics, and Engineerin
Vol. 61, Issue II, June, 2018

ATTENUATION OF NOISE POLLUTION IN AN INDUSTRIAL HALL, BY FITTING A FICUS BUSHES OF CURTAINS

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Abstract: *The aim of this work is the study of the absorption of noise pollution from an industrial Hall by installing a barrier-a wall of green plants consisting of shrubs of the Ficus (Ficus Benjamina)*
Key words: *attenuation of noise pollution, industrial hall, sound-absorption panel, Ficus Benjamina.*

1. INTRODUCTION

Sound pollution in industrial halls produces imbalances throughout the body in human with temporary or permanent effects [1]. It produces sleep disturbance, anxiety, depression, heart rhythm disorders, neurosis, glandular poison, muscle hypertonia, hyperactivity and especially sensorineural hearing loss or perception.

The European Community adopted Directive No. 86/188 concerning protection of employees against the risks of illness due to exposure to noise in the workplace, which establishes that exposure limit value of 85 dB NAEC/week [1].

NAEC is the Romanien expresion = Nivelul Acustic Echivalent Continuu pe săptămână -, and is the level of a constant acoustic noise that acts continuously on all week and has an auditory effect similar to variable noise in the workplace.

2. GENERAL CONSIDERATIONS

Sound pollution in industrial halls acts on the human body, serving industrial equipment noise, or employer, which are vast in the immediate neighbourhood of the equipment that is needed reducing noise through various means, that not to impair the functioning of the machine and which not to alter the status overall health of the human operator [2].

In the paper is studying from a pollutant factor in the industrial hall, which is a flexographic printing machine, size 9.8 m x 5.6 m x 4.3 m, and during operation that produces a sound pressure which varies between 81-92 dB, according to measurements made, in situ [2].

The paper shows the simulation in MATLAB Simulink of sound absorption by a curtain from the species of Ficus Benjamina, which represents a phonoabsorbant barrier in the path of an industrial machine that produces a strong sound pollution.

For the Ficus Benjamina shrub the absorption coefficient is estimated experimentally and it is centralized in table 1 for various frequencies.

Table 1.
Absorption coefficient for Ficus Benjamina shrub

	Absorbtion Coefficientul					
Frequency [Hz]	125	250	500	1000	2000	4000
Ficus Benjamina	0,06	0,06	0,1	0,19	0,22	0,57

The transmission coefficient is estimated approximately from [1], with the relation:

$$A_{gr} = 4{,}8\, f - \left(\frac{2h_m}{d}\right)\left[17 + \left(\frac{300}{d}\right)\right] \geq 0\ [dB] \quad (1)$$

In this relationship the notations significance is: A_{gr} – the absorption coefficient is centralized in table 1; h_m – transmission coefficient; d – the distance from the source; f – source frequency.

For Ficus Benjamina is determined the transmission coefficient using the relationship (1) and with the use of the coefficient of absorption centralized in table 1. The result is given in the table 2.

Table 2.
Transmission coefficient for Ficus Benjamina shrub

	Transmission Coefficientul					
Frequency [Hz]	125	250	500	1000	2000	4000
Ficus Benjamina	0,65	0,57	0,42	0,37	0,29	0,21

2.1. Positioning of Sound Absorbing Barrier

Consider the location of the equipment, which is the source of noise, plays in Figure 1, and in the opening from which equipment is punctuated in drawing, will post a sound-absorbing panel which shall consist of Ficus Benjamina shrub.

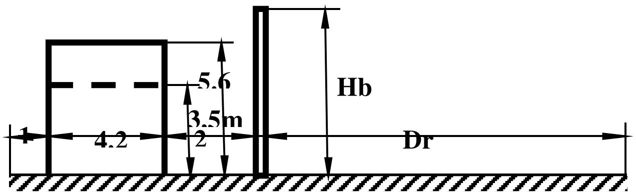

Fig. 1. Diagram of the sound-absorbing barrier. The approach towards. 1-the source of the noise; 2-fonoabsorbantă barrier; HB-height barrier; Dr-distance to the receiver; X_0-share input sound barrier; X_1-sound output listing from barrier.

Studies on the absorption of sound waves moving through the different mediums, and is exponentially diminution depends on sound-absorbing material of the panel.

Sound waves are hitting the barrier/veil from plant material. Here they suffer some transformations: the reflection, the absorbed (as in table 1), the transmission (Table 2), and finally part of them diffract, or refract to the surface barrier/veil.

Between the absorption coefficient - labeled "a"; - the transmission - labeled "t" - and the coefficient of reflection - labeled "r" - there are a linear relationship. Their sum is constant and equal with "1".

$$1 = a + t + r \qquad (2)$$

The sound wave propagates after law:

$$p(x,t) = \begin{cases} \left(A \cdot e^{-a_1 \cdot x} \cdot \cos\left(\omega t - \frac{\omega}{c} \cdot x\right)\right) & \text{if } x \le x_0 \\ \left[(1-r) A \cdot e^{-a_1 \cdot x_0} \cdot e^{-a_2 \cdot (x - x_0)} \cdot \cos\left(\omega t - \frac{\omega}{c} \cdot x\right)\right] & \text{if } (x > x_0 \wedge x < x_1) \\ \left[(1-r) \cdot \tau \cdot A \cdot e^{-a_1 \cdot x_0} \cdot e^{-a_2 \cdot (x_1 - x_0)} \cdot e^{-a_3 \cdot (x - x_1)} \cdot \cos\left(\omega t - \frac{\omega}{c} \cdot x\right)\right] & \text{otherwise} \end{cases} \qquad (3)$$

Oscillation amplitude variation has the expression:

$$A_{dl}(x) := \begin{cases} A \cdot e^{-a_1 \cdot x} & \text{if } x < x_0 \\ (1-r) \cdot A \cdot e^{-a_1 \cdot x_0} \cdot e^{-a_2 \cdot (x - x_0)} & \text{if } [(x \ge x_0) \wedge (x < x_1)] \\ (1-r) A \cdot e^{-a_1 \cdot x_0} \cdot e^{-a_2 \cdot (x_1 - x_0)} \cdot e^{-a_3 \cdot (x - x_1)} & \text{otherwise} \end{cases} \qquad (4)$$

3. SIMULATION OF NOISE POLLUTION ABSORPTION THROUGH THE VEGETABLE PANEL OF THE FICUS BENJAMINA STRUB

It will analyze the plant panel of sound-absorbing made by Ficus Benjamina shrub, with 50 cm thick, considering a receiver located at the 2-position, i.e. at 3.5 m and 10 m distance from the green wall to the receiver, depending on different frequencies. The frequencies are: 125Hz, 250Hz, 500Hz, 1000Hz, 2000Hz, and 4000Hz. The graphical representations are given in the following figures.

3.1. The Barrier from the Ficus Benjamina with the Receiver located at 3,5 m Frontages Source

Each representation of only one frequency is shown in a figure in the following sequence. In the figure 2 is given for 125Hz, in the figure 3 is given for 250Hz, in the figure 4 for 500Hz, in the figure 5 for 1000Hz, in the figure 6 for 2000Hz, and in the figure 7 for 4000Hz.

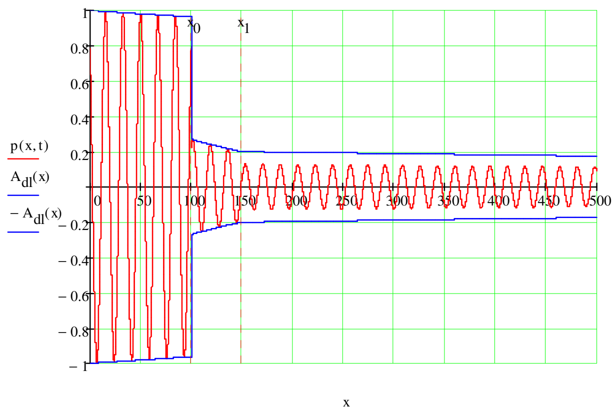

Fig. 2. Attenuation due to the barrier of 50 cm from the Ficus Benjamina, at the 125Hz frequency, receiver located at the 3.5m frontage source

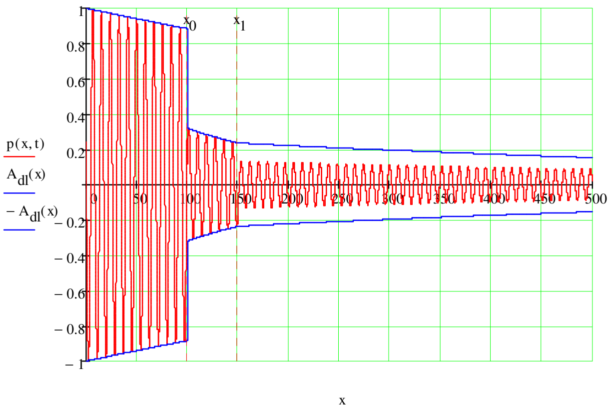

Fig. 3. Attenuation due from the Ficus Benjamina, at the 250Hz frequency, receiver at 3.5m to source

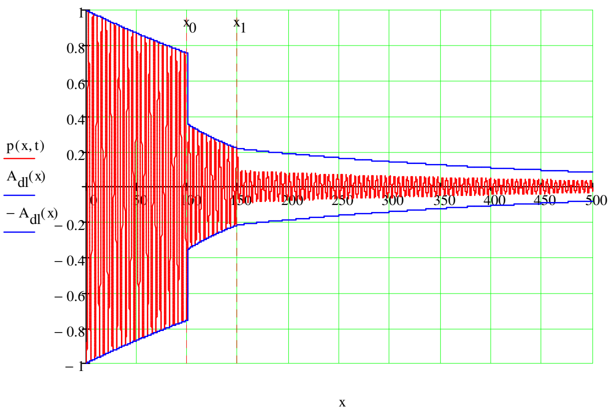

Fig. 4. Attenuation from the Ficus Benjamina, at the 500Hz frequency, receiver located at the 3.5m frontage source

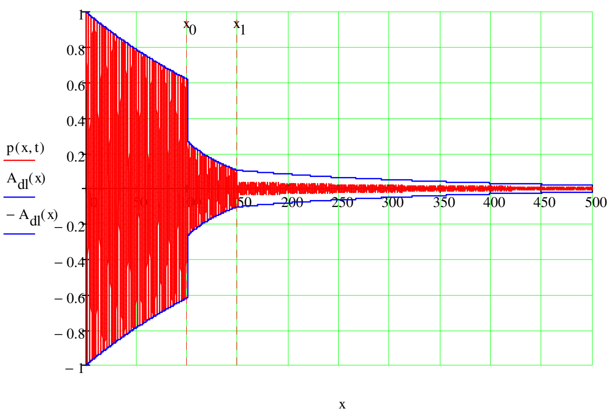

Fig. 5. Attenuation due to the barrier of 50 cm from the Ficus Benjamina, at the 1000Hz frequency, receiver located at the 3.5m frontage source

3.2. The Barrier from the Ficus Benjamina with the Receiver located at 10m Frontages Source

Each representation of only one frequency is shown in a figure in the following sequence, between 8 and 13.

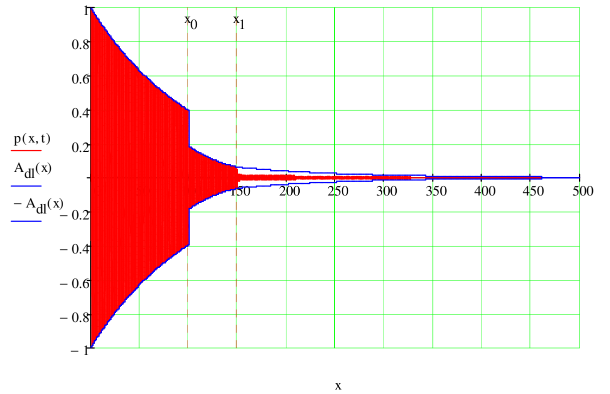

Fig. 6. Attenuation due from the Ficus Benjamina, at the 2000Hz frequency, receiver at 3.5m to source

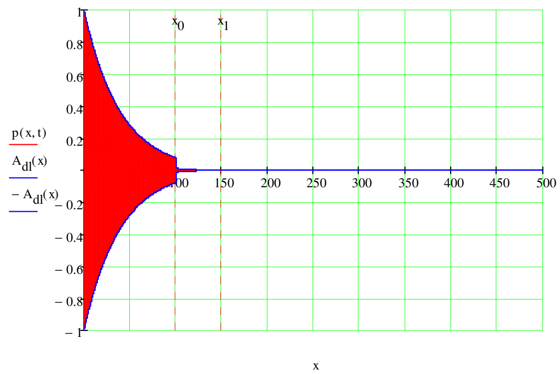

Fig. 7. Attenuation due from the Ficus Benjamina, at the 4000Hz frequency, receiver at 3.5m to source

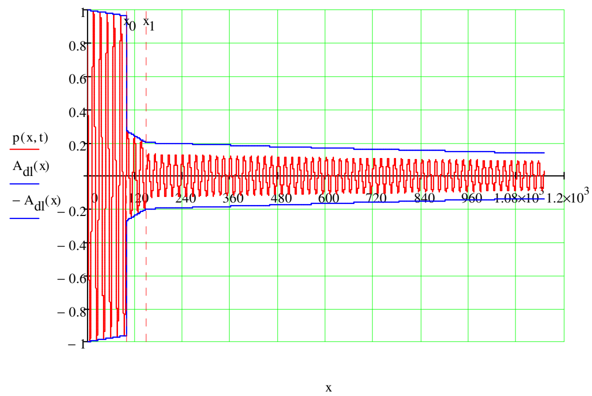

Fig. 8. Attenuation due from the Ficus Benjamina, at the 125Hz frequency, receiver at 10m to source

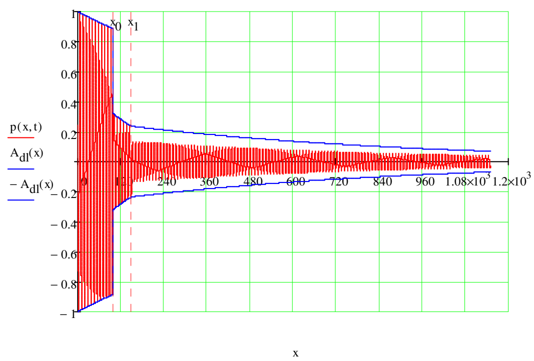

Fig. 9. Attenuation due from the Ficus Benjamina, at the 250Hz frequency, receiver at 10m to source

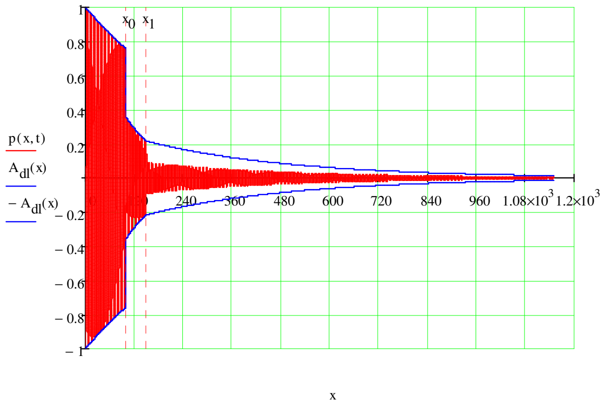

Fig. 10. Attenuation due from the Ficus Benjamina, at the 500Hz frequency, receiver at 10m to source

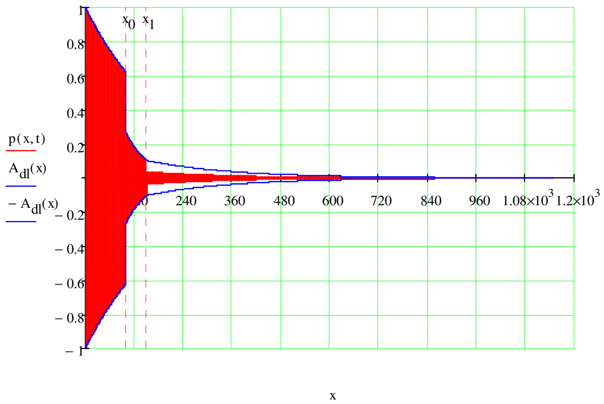

Fig. 11. Attenuation due from the Ficus Benjamina, at the 1000Hz frequency, receiver at 10m to source

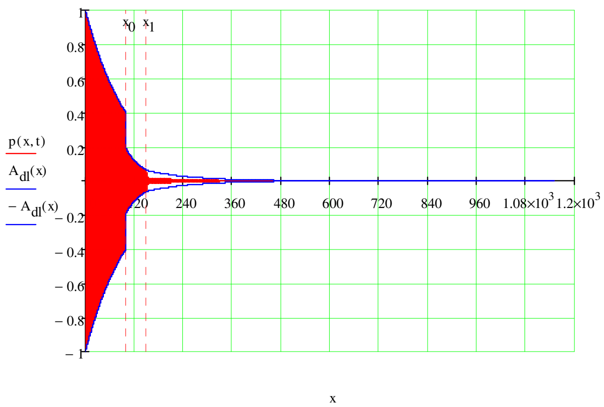

Fig. 12. Attenuation due from the Ficus Benjamina, at the 2000Hz frequency, receiver at 10m to source

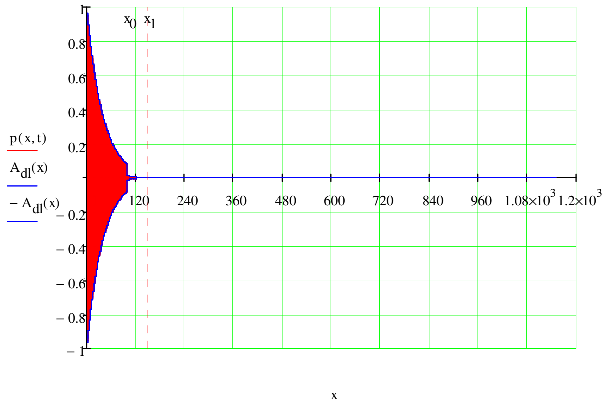

Fig. 13. Attenuation due from the Ficus Benjamina, at the 4000Hz frequency, at the 10m to source

4. CONCLUSIONS ON THE ATTENUATION OF THE SOUND OF THE FICUS BENJAMINA

From sound-absorbing panels for representations made from Ficus Benjamina shrub, they can conclude the following:

1. The Ficus Benjamina shrub is a powerful noise attenuator, and attenuation is a function of the frequency of the source;
2. Attenuation is stronger for higher frequencies and lower for lower frequencies;
3. At frequencies of 4000 Hz source, noise attenuation occurs in the curtain and thus work in industrial hall behind the veil can be made.

5. REFERENCES

[1] Lupas Arabela-Adriana, Raport 1 de cercetare stiintifica – *Studiu documentar asupra poluarii sonore in halele industriale in vederea protectiei mediului*, Scoala doctorala UTCN, septembrie, 2014;

[2] Lupas Arabela-Adriana, Raport 3 de cercetare stiintifica – *Studiu experimental asupra poluarii sonore in halele industriale in vederea protectiei mediului*, Scoala doctorala UTCN, septembrie, 2015.

Atenuarea poluarii sonore intr-o hala industriala, printr-o perdele din arbusti de ficus

Rezumat: Scopul acestei lucrarii este studiul absorbtiei poluarii sonore dintr-o hala industriala prin montarea unei bariere verzi – un perete de plante format din arbusti de ficusi (Ficus Benjamina)

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