TECHNICAL UNIVERSITY OF CLUJ-NAPOCA

ACTA TECHNICA NAPOCENSIS

Series: Applied Mathematics, Mechanics, and Engineering
Vol. 58, Issue III, September, 2015

ANALYZE OF NOISE BARRIER INFLUENCE ON THE LINEAR SOURCES

Alin-Cosmin TOT, Mariana ARGHIR

Abstract: *This paper aims to quantify the influence of the theory of noise barriers mounted along linear sources. For this purpose were analyzed four types of barriers with heights of two meters at the same time, comparing the influence of sound-absorbing structures, if mounting the barrier on the surface of these structures in the vicinity of the incident wave front. Thus, the analysis of acoustic condition was achieved at frequencies of 100, 150 and 250 Hz. sound absorbing structures Coefficients are 0.2, for frequency of 100 Hz and 0.5 for the frequencies of 150 and 250Hz.*
Key words: *noise barriers, FME, linear noise sources*

1. INTRODUCTION

This paper aims to quantify the influence of the theory of noise barriers mounted along linear sources. For this purpose were analyzed four types of barriers with heights of two meters at the same time, comparing the influence of sound-absorbing structures, if mounting the barrier on the surface of these structures in the vicinity of the incident wave front. Thus, the analysis of acoustic condition was achieved at frequencies of 100, 150 and 250 Hz. sound absorbing structures Coefficients are 0.2, for frequency of 100 Hz and 0.5 for the frequencies of 150 and 250Hz.

Analysis of the noise influence of the four types of barriers were considered a variant of the elements (source and receiver barrier), which can be seen in the case of highways (Fig.1, Fig. 2, Fig. 3, and Fig. 4).

If it is considered the fact, that the movement of motor vehicles on a highway generates a waveform with a semicircular profile, sound source used was designed as a circle with a radius of 1.75 m, set on width of a sense. Noise barriers were placed at a distance of 3.5 m towards the sound source. Acoustic shielding capacity barriers have been analyzed from 1 up to 10 m away behind the barrier, to the heights of 0.5, 0.7 and 1.7 m from the ground. The influence of the acoustic environment it was established in barrier front highlighted by indicating the maximum values encountered at heights of 0, 1, 2, 3, 4, 5, 6 and 7 m from the ground.

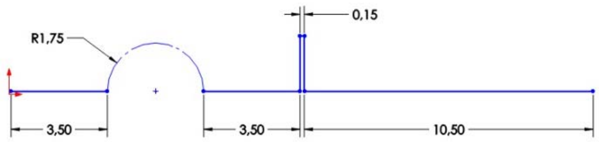

Fig. 1 Barrier Type “I”

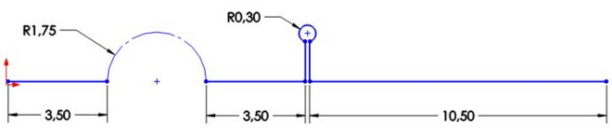

Fig. 2 Barrier Type “O”

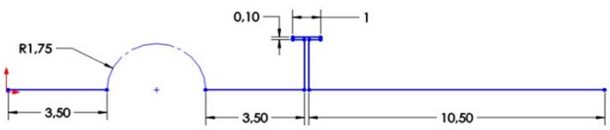

Fig. 3 Barrier Type “T”

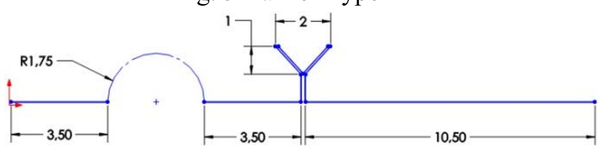

Fig. 4 Barrier Type “Y”

2. BACKGROUND THEORY

Acoustic analysis of sound field in a defined space can be described by Helmholtz the relationship:

$$\nabla^2 P + k^2 P = 0 \qquad (1)$$

Where P – is sound pressure, k – is wave number, ∇ - is Laplace operator.

If you consider the density environment, the Helmholtz equation becomes:

$$\nabla \cdot \left(\frac{1}{\rho_0}\nabla P\right) + \frac{1}{\rho_0}\left(\frac{\omega}{c}\right)^2 P = 0 \qquad (2)$$

In this relation: ρ_0 – reference density, ω – pulsation.

For solving the Helmholtz equation, are required the boundary conditions. Boundary conditions are established between the field of modeling and a perfect reflecting wall, which in this case is noise barriers and surface soil, and the normal derivative of the pressure, is zero, on these limits:

$$n \cdot \left(\frac{1}{\rho}(\nabla P)\right) = 0 \qquad \frac{\partial P}{\partial n} = 0 \qquad (3)$$

In this relations, the “n” is noted the normal vector on the direction of travel.

Node of planar wave radiation plus a radiation boundary condition at limit, for to leave the field of modeling with minimum reflectance, when the angle of incidence is close to its normal.

$$n \cdot \left(\frac{1}{\rho}\nabla P\right) + i\frac{\omega P}{c\,\rho} = 0 \qquad (4)$$

For boundary conditions between the modeling field and the surface of a wall that generates noise shall take account of the fact that nodes located along the dividing surface between the field and the surface noise source is:

$$n \cdot \left(\frac{1}{\rho}(\nabla P)\right) = i\omega U \qquad (5)$$

Boundary conditions between the field of modeling and acoustic barrier surface impedance known, are given for node, as follows:

$$n \cdot \left(\frac{1}{\rho}(\nabla P)\right) = -P\frac{i\omega}{Z_i} \qquad (6)$$

Z_i is the acoustic impedance of the given element outside of the domain [Pa*s/m].

As regards the expression of difference pressure between the amplitude of incidents pressure (P_i) and the magnitude of pressure found in the field of modeling (P_m) is used the relationship of literature, known through the [KOO-10], [HAR-11], [SAL-15], [SIS-12], [KRI-10], [FAU-02], [STR -13].

$$dB = 20\log_{10}\frac{|Pi|}{|Pm|} \qquad (7)$$

3. ANALYSIS OF THE ACOUSTIC ENVIRONMENT

The figures follow, represent the front behavior analysis (outlined with black lines), that propagates from the edges of the source domain, stressing the absolute sound pressure amplitude difference (absolute pressure wave front incident) by Rainbow color palette, for barriers with type „I”, „O”, „T” and „Y”.

Are analysed each type of barrier in part, and in which cases these barriers have a sound-absorbing material attached on the surface from the source.

3.1. Analysis of the noise propagation influenced of type „I” barriers

Graphical representation of acoustic wave propagation affected by barriers of type I with a height of 2 m.

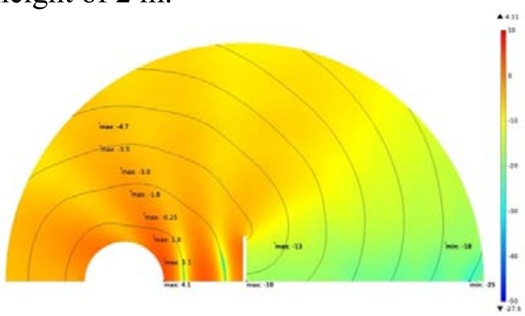

Fig. 5 Barrier type I with 2 m height, without sound absorption materials and 100Hz frequency sound

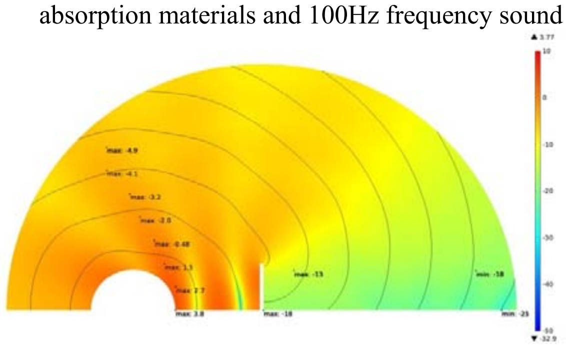

Fig. 6 Barrier type I with a height of 2 m, with sound absorption materials and 100Hz frequency sound

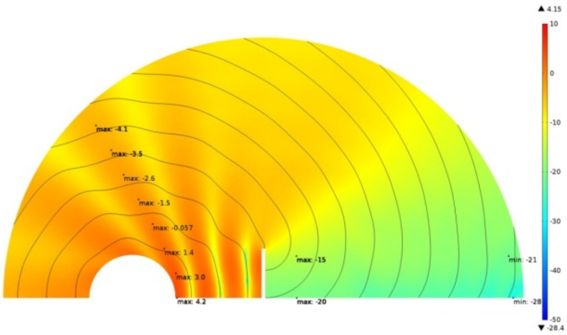

Fig. 7 Barrier type I with 2 m height, without sound absorption materials and 150Hz frequency sound

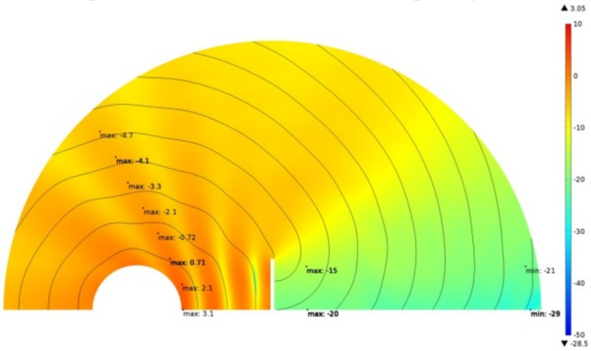

Fig. 8 Barrier type I with a height of 2 m, with sound absorption materials and 150Hz frequency sound

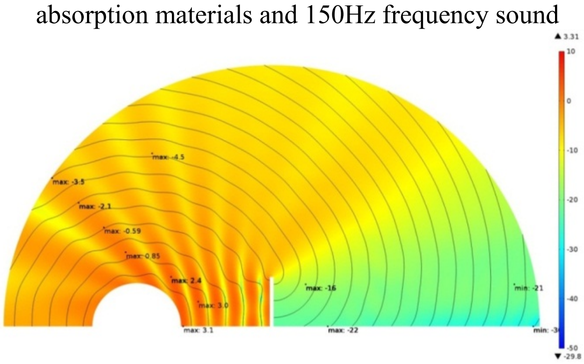

Fig. 9 Barrier type I with 2 m height, without sound absorption materials and 250Hz frequency sound

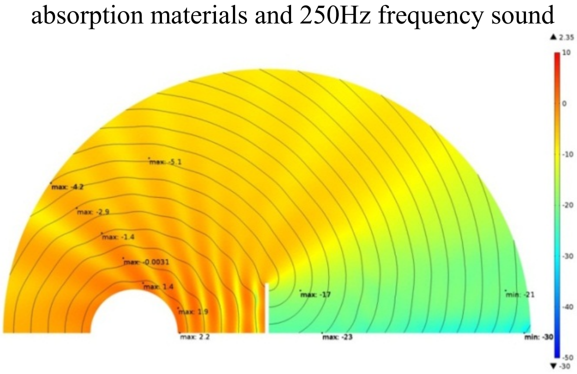

Fig. 10 Barrier type I with a height of 2 m, with sound absorption materials and 250Hz frequency sound

3.2. Analysis of the noise propagation influenced of type „O" barriers

Graphical representation of acoustic wave propagation affected by barriers of type „O" with a height of 2 m.

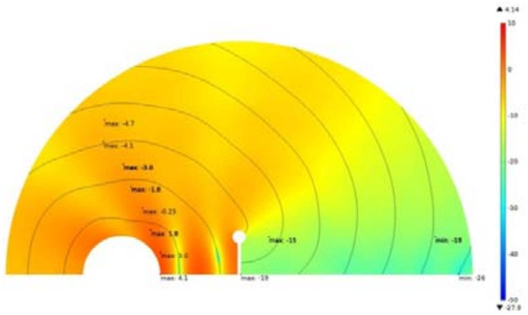

Fig. 11 Barrier type O with 2 m height, without sound absorption materials and 100Hz frequency sound

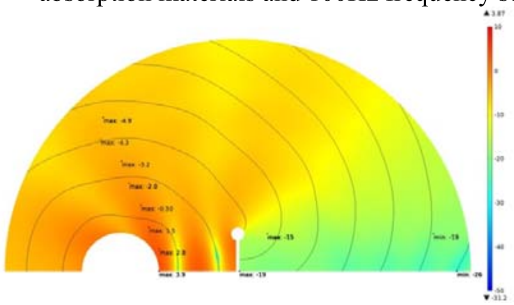

Fig. 12 Barrier type O with a height of 2 m, with sound absorption materials and 100Hz frequency sound

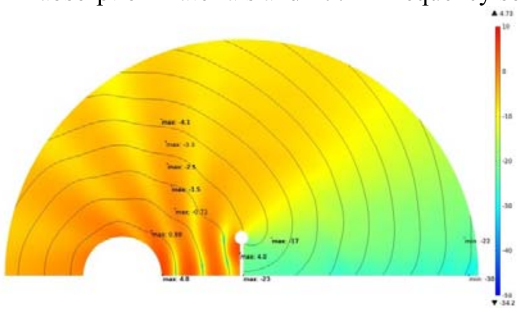

Fig. 13 Barrier type O with 2 m height, without sound absorption materials and 150Hz frequency sound

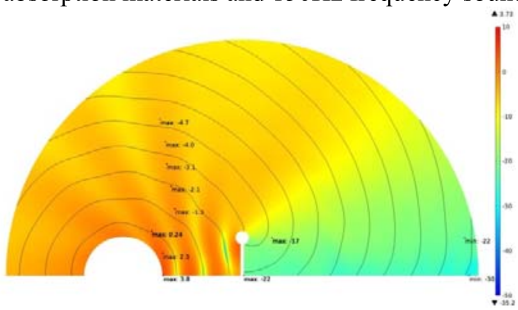

Fig. 14 Barrier type O with a height of 2 m, with sound absorption materials and 150Hz frequency sound

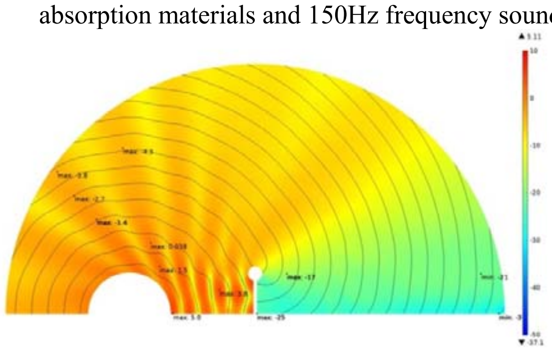

Fig. 15 Barrier type O with 2 m height, without sound absorption materials and 250Hz frequency sound

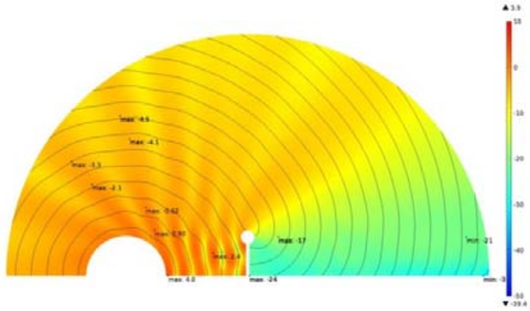

Fig. 16 Barrier type O with a height of 2 m, with sound absorption materials and 250Hz frequency sound

3.3. Analysis of the noise propagation influenced of type „T” barriers

Graphical representation of acoustic wave propagation affected by barriers of type „T” with a height of 2 m.

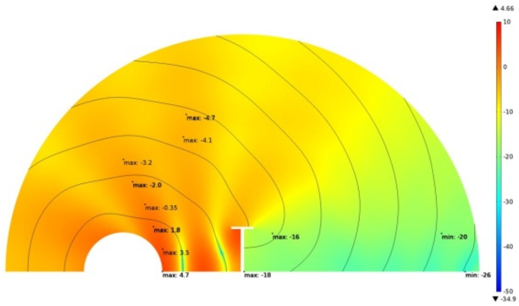

Fig. 17 Barrier type T with 2 m height, without sound absorption materials and 100Hz frequency sound

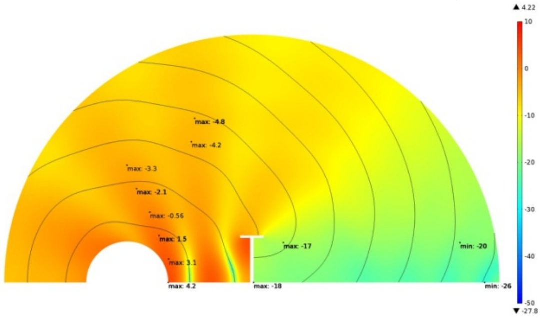

Fig. 18 Barrier type T with a height of 2 m, with sound absorption materials and 100Hz frequency sound

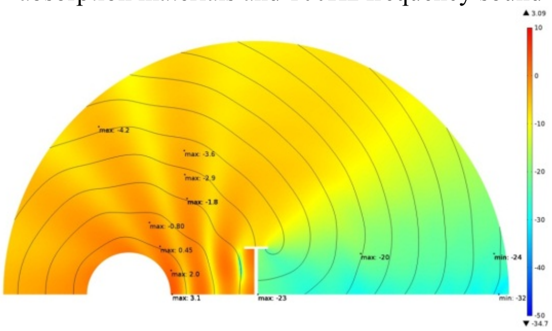

Fig. 19 Barrier type T with 2 m height, without sound absorption materials and 150Hz frequency sound

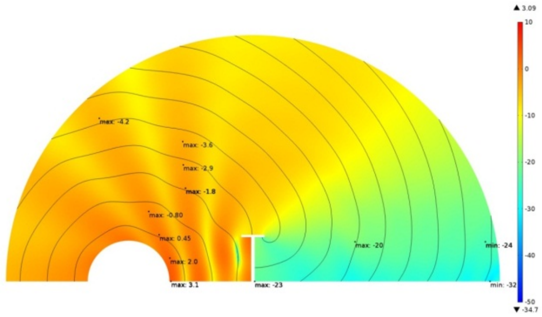

Fig. 20 Barrier type T with a height of 2 m, with sound absorption materials and 150Hz frequency sound

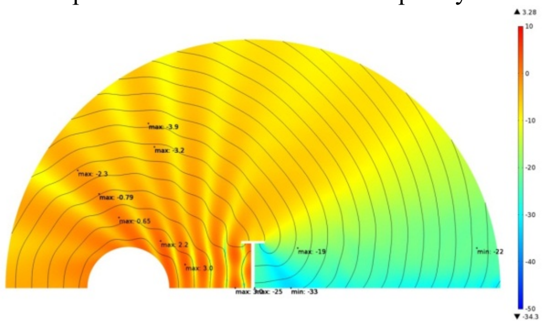

Fig. 21 Barrier type T with 2 m height, without sound absorption materials and 250Hz frequency sound

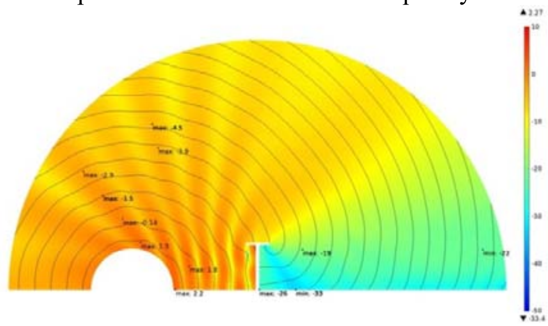

Fig. 22 Barrier type T with a height of 2 m, with sound absorption materials and 250Hz frequency sound

3.4. Analysis of the noise propagation influenced of type „Y” barriers

Graphical representation of acoustic wave propagation affected by barriers of type „T” with a height of 2 m.

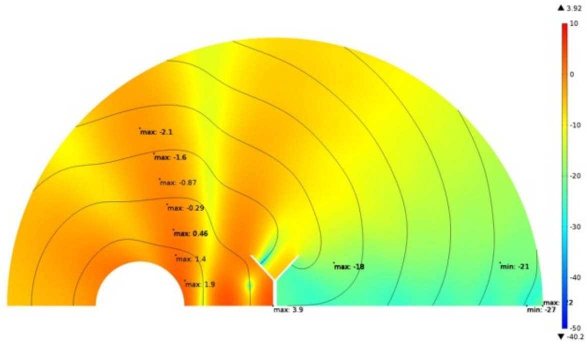

Fig. 23 Barrier type Y with 2 m height, without sound absorption materials and 100Hz frequency sound

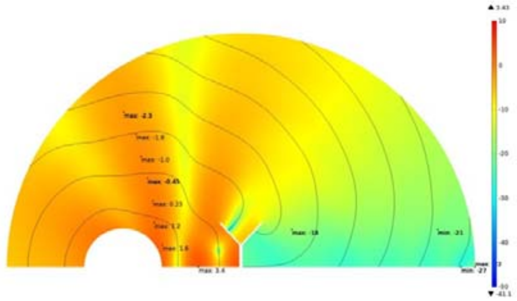

Fig. 24 Barrier type Y with a height of 2 m, with sound absorption materials and 100Hz frequency sound

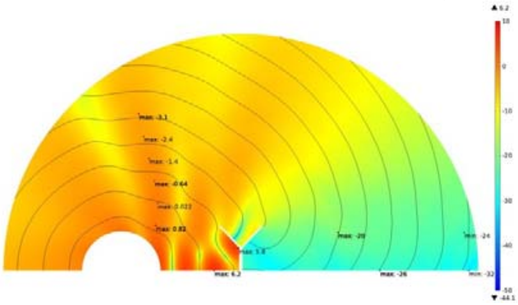

Fig. 25 Barrier type Y with 2 m height, without sound absorption materials and 150Hz frequency sound

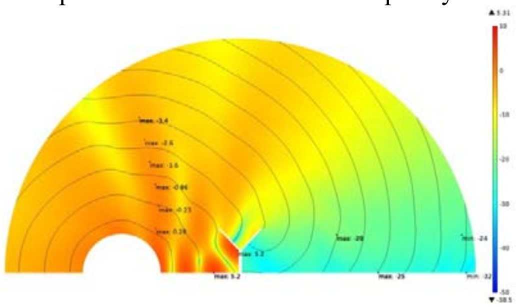

Fig. 26 Barrier type Y with a height of 2 m, with sound absorption materials and 150Hz frequency sound

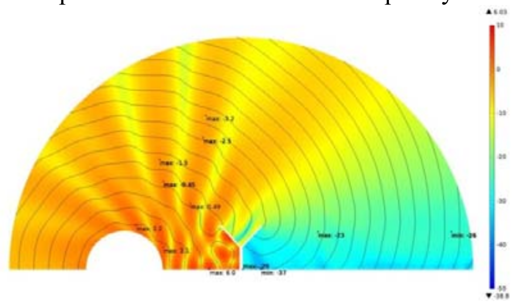

Fig. 27 Barrier type Y with 2 m height, without sound absorption materials and 250Hz frequency sound

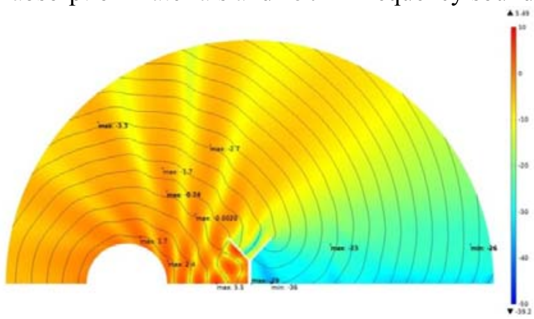

Fig. 28 Barrier type Y with a height of 2 m, with sound absorption materials and 250Hz frequency sound

3.5. The influence of noise barriers over the environmental acoustic in the carriageway

Maximum sound pressure differences observed on 8 levels (found in heights of 0, 1, 2, 3, 4, 5, 6 and 7 m from the ground), located in front of the barrier are presented in the table below.

Table 1.

Maximum sound pressure differences, observed on the 8 positions located in front of the barrier

Fig. No.	Receptors in the face of the barrier heights of							
	0 [m]	1 [m]	2 [m]	3 [m]	4 [m]	5 [m]	6 [m]	7 [m]
5.	4.1	3.1	1.8	-0.25	-1.8	-3.0	-3.9	-4.7
6.	4.2	3.0	1.4	-0.05	-1.5	-2.6	-3.5	-4.1
7.	3.1	3.0	2.4	0.85	-0.59	-2.1	-3.5	-4.5
8.	3.8	2.7	1.5	-0.48	-2.0	-3.2	-4.1	-4.9
9.	3.1	2.1	0.71	-0.72	-2.1	-3.3	-4.1	-4.7
10.	2.2	1.9	1.4	0	-1.4	-2.9	-4.2	-5.1
11.	4.1	3.0	1.8	-0.25	-1.8	-3.0	-4.1	-4.7
12.	4.8	4.0	0.88	-0.72	-1.5	-2.5	-3.3	-4.1
13.	4.8	4.0	0.88	-0.72	-1.5	-2.5	-3.3	-4.1
14.	3.9	2.8	1.5	-0.50	-2.0	-3.2	-4.3	-4.9
15.	3.8	2.3	0.24	-1.3	-2.1	-3.1	-4.0	-4.7
16.	4.0	2.4	0.90	-0.62	-2.1	-3.3	-4.1	-4.5
17.	4.7	3.5	1.8	-0.35	-2.0	-3.2	-4.1	-4.7
18.	3.6	2.5	0.45	-0.80	-1.8	-2.7	-3.6	-4.3
19.	3.0	3.0	2.2	0.65	-0.79	-2.3	-3.2	-3.9
20.	4.2	3.1	1.5	-0.56	-2.1	-3.3	-4.2	-4.8
21.	3.1	2.0	0.45	-0.1	-1.8	-2.9	-3.5	-4.2
22.	2.2	1.8	1.3	-0.14	-1.5	-2.9	-3.9	-4.5
23.	3.9	1.8	1.4	0.46	-0.29	-0.8	-1.6	-2.1
24.	6.2	5.8	0.8	0	-0.6	-1.4	-2.4	-3.1
25.	6.0	3.1	2.2	0.49	-0.45	-1.5	-2.5	-3.2
26.	3.4	1.6	1.2	0.25	-0.45	-1.0	-1.8	-2.3
27.	5.2	5.2	0.28	-0.23	-0.86	-1.6	-2.6	-3.4
28.	5.4	2.4	1.7	0	-0.74	-1.7	-2.7	-3.3

These results, expressed in dB, were obtained on the basis of the (7) relationship, defining absolute difference acoustic pressure amplitudes in the field of modeling compared to the absolute sound pressure of the wave front generated by linear noise source. In this case is the noise of traffic on highways encountered.

4. SHIELDING ABILITY OF ANALYZED NOISE BARRIERS

The following are comparisons between screening ability of noise barriers and influence of sound-absorbing structures mounted on them. Comparison of the results obtained at the level of the receiver located behind the barrier-type „I” (Fig. 29, 30, 31), type „O” (Fig. 32, 33, 34), type „T” (Fig. 35, 36, 37), and finally type „Y” (Fig. 38, 39, 40).

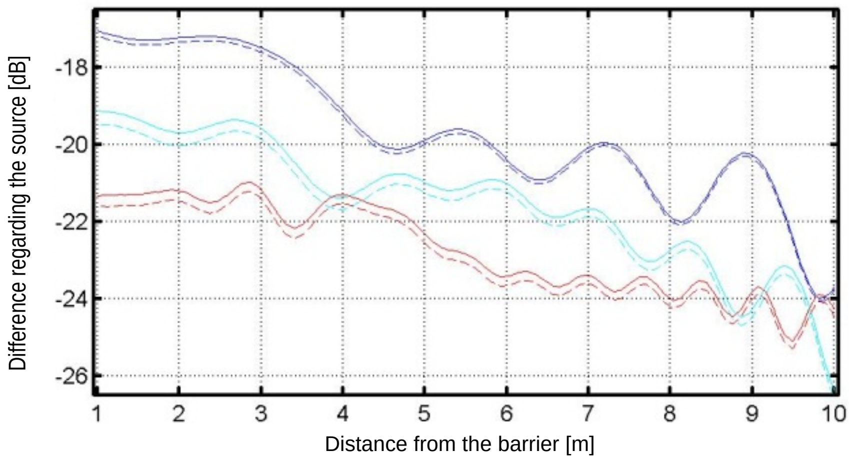

Fig. 29 The difference of the sound pressure level at the receptor located at 0.5 m from the ground, behind the barrier type "I" with a height of 2 m, for frequencies 100, 150 şi 250Hz, - - with şi --- without phonoabsorbant material

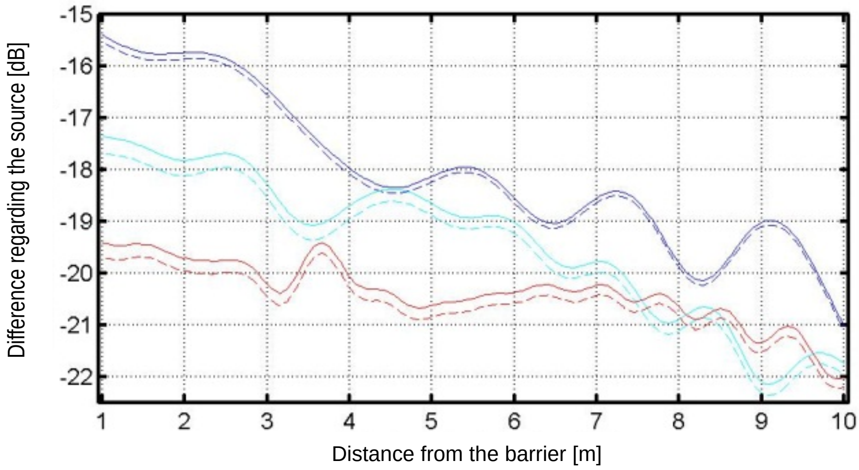

Fig. 30 The difference of the sound pressure level at the receptor located at 1.1 m from the ground, behind the barrier type "I" with a height of 2 m, for frequencies 100, 150 şi 250Hz, - - with şi --- without phonoabsorbant material

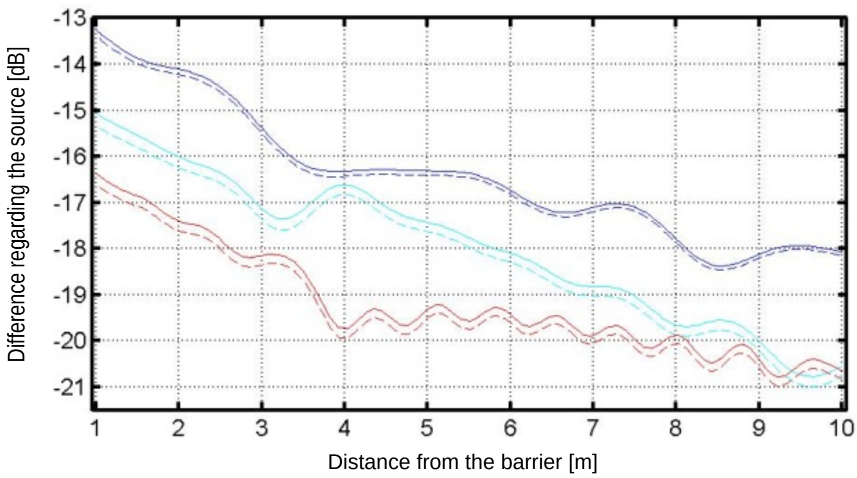

Fig. 31 The difference of the sound pressure level at the receptor located at 1.7 m from the ground, behind the barrier type "I" with a height of 2 m, for frequencies 100, 150 şi 250Hz, - - with şi --- without phonoabsorbant material

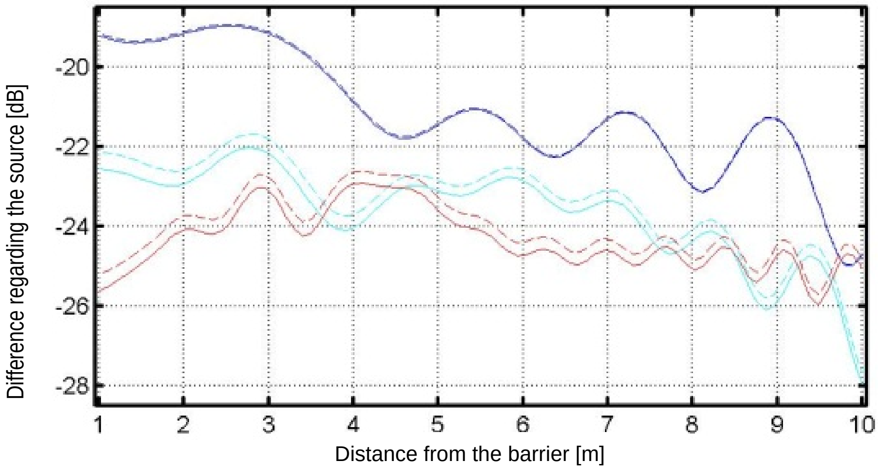

Fig. 32 The difference of the sound pressure level at the receptor located at 0.5 m from the ground, behind the barrier type “O” with a height of 2 m, for frequencies 100, 150 şi 250Hz, - - with şi --- without phonoabsorbant material

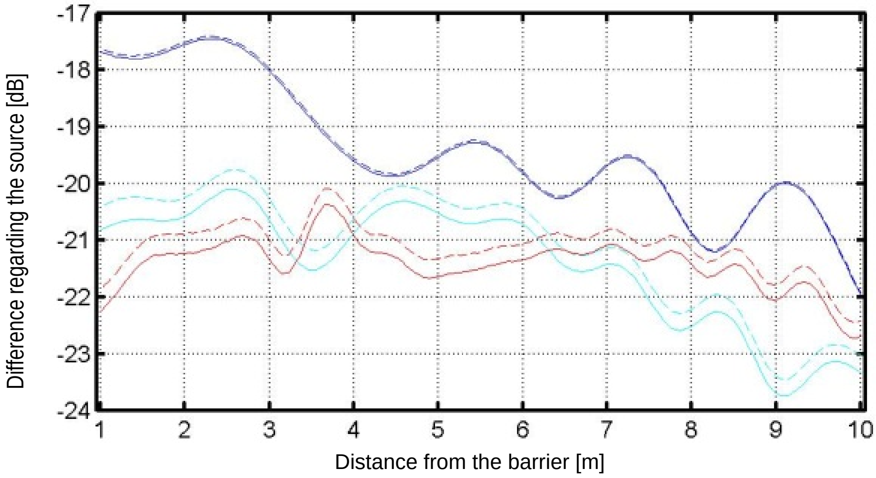

Fig. 33 The difference of the sound pressure level at the receptor located at 1.1 m from the ground, behind the barrier type “O” with a height of 2 m, for frequencies 100, 150 şi 250Hz, - - with şi --- without phonoabsorbant material

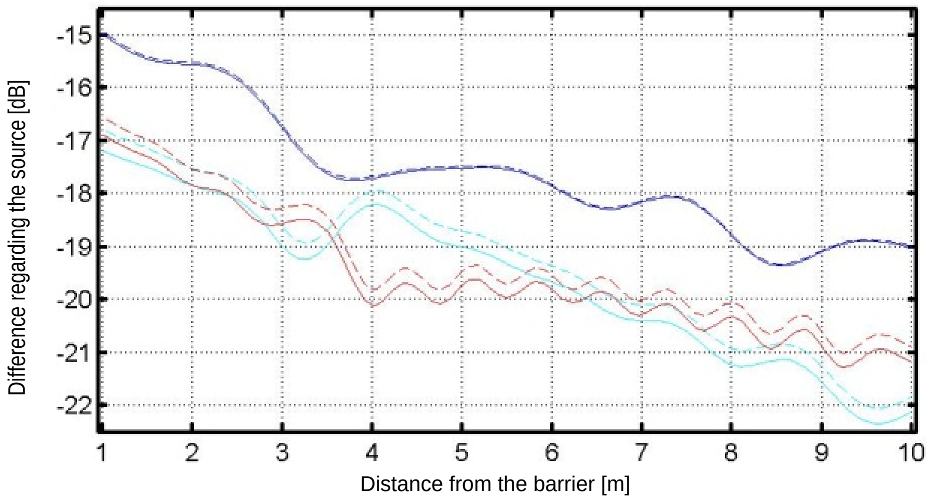

Fig. 34 The difference of the sound pressure level at the receptor located at 1.7 m from the ground, behind the barrier type “O” with a height of 2 m, for frequencies 100, 150 şi 250Hz, - - with şi --- without phonoabsorbant material

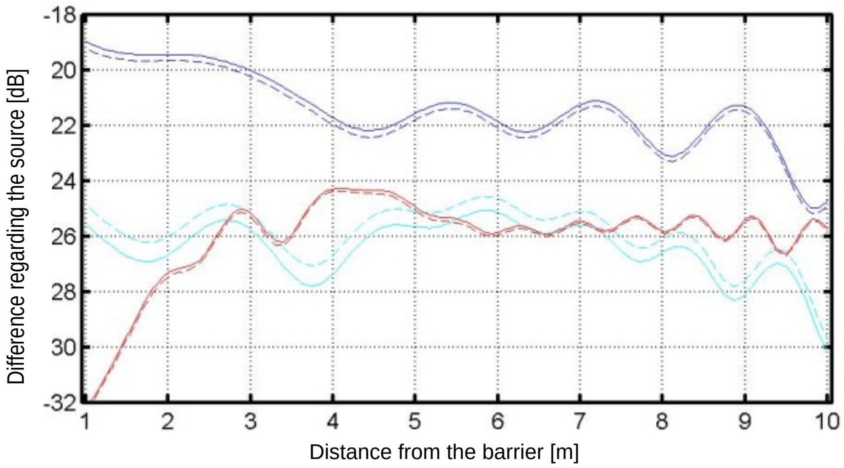

Fig. 35 The difference of the sound pressure level at the receptor located at 0.5 m from the ground, behind the barrier type “T” with a height of 2 m, for frequencies 100, 150 şi 250Hz, - - with şi --- without phonoabsorbant material

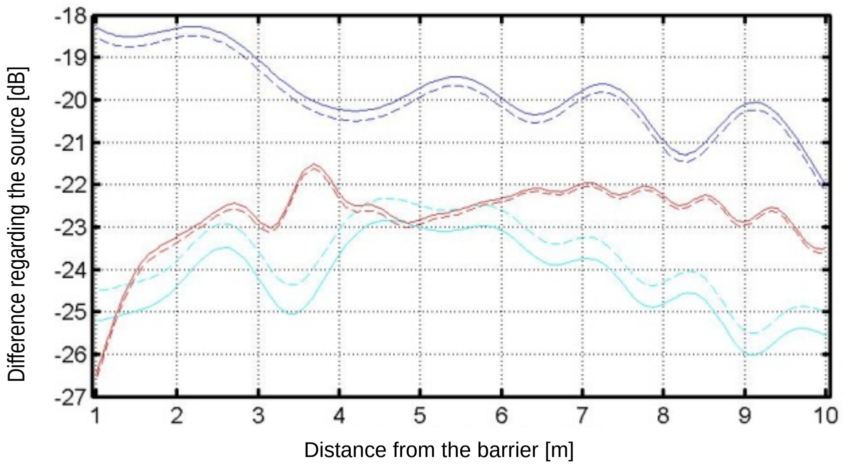

Fig. 36 The difference of the sound pressure level at the receptor located at 1.1 m from the ground, behind the barrier type “T” with a height of 2 m, for frequencies 100, 150 şi 250Hz, - - with şi --- without phonoabsorbant material

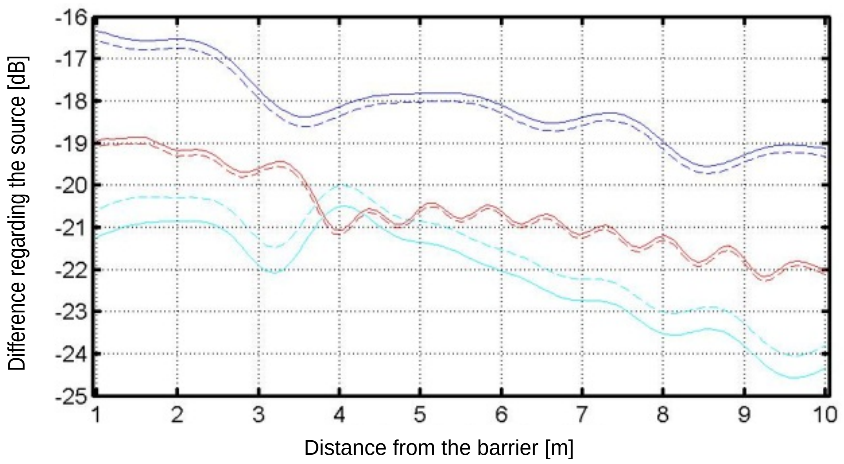

Fig. 37 The difference of the sound pressure level at the receptor located at 1.7 m from the ground, behind the barrier type “T” with a height of 2 m, for frequencies 100, 150 şi 250Hz, - - with şi --- without phonoabsorbant material

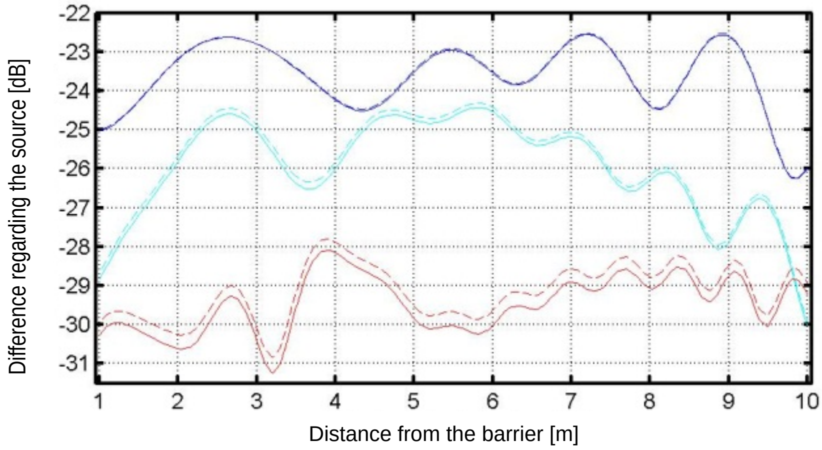

Fig. 38 The difference of the sound pressure level at the receptor located at 0.5 m from the ground, behind the barrier type “Y” with a height of 2 m, for frequencies 100, 150 şi 250Hz, - - with şi --- without phonoabsorbant material

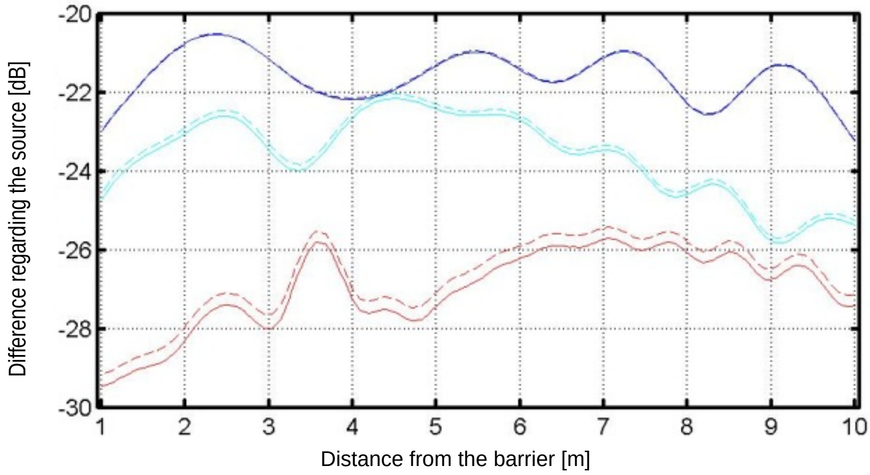

Fig. 39 The difference of the sound pressure level at the receptor located at 1.1 m from the ground, behind the barrier type “Y” with a height of 2 m, for frequencies 100, 150 şi 250Hz, - - with şi --- without phonoabsorbant material

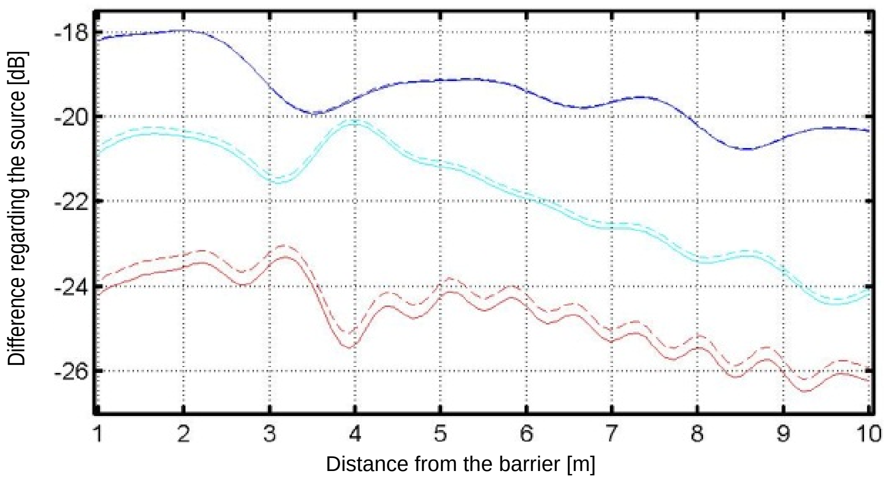

Fig. 40 The difference of the sound pressure level at the receptor located at 1.7 m from the ground, behind the barrier type “Y” with a height of 2 m, for frequencies 100, 150 şi 250Hz, - - with şi --- without phonoabsorbant material

5. CONCLUSIONS

The influence of noise barriers on the propagation produced by linear sound sources of the pollutant, it can be concluded by the following aspects:

1. In terms of noise barriers encountered on the roadway noise, they have an influence as diminishe (by deduction, by reducing noise) as can be seen in table 1, as well as in figures illustrating the noise propagation analysis;
2. From the point of view of roadway noise encountered on sound absorbing structures located on the face of the barrier does not have a significant influence especially in the area of soil;
3. From the point of view of mitigation capacity in all cases analysed in this chapter shows significant attenuation of noise;
4. As shown in the graphs corresponding to acoustic barrier, in all cases the influence of sound absorbing structure placed on the front side of the barrier is not significant in terms of mitigating noise behind the barrier;
5. In all cases the barrier with „Y" or „T" profile, has a linear trend in the level of shielding the length of 1-10m;
6. „Y"- type barrier, equipped with sound-absorbing material in the front (toward the source) to produce a total sound mitigation length greater than 10 m, any height, so it makes total efficiency.

6. ACKNOWLEDGEMENT: This paper is supported by the Sectorial Operational Programme Human Resources Development POSDRU/159/1.5 / S / 137516 financed from the European Social Fund and by the Romanian Government.

7. BIBLIOGRAPHY / REFERENCES

[KOO-10] Junghwan KOOK, Kunmo KOO, Jaeyup YUN, Sang-Myeong KIM, Semyung WANG; acoustic topology optimization of noise barrier by considering zwicker's loudness, International Congress on sound & vibration, Department of Mechatronics, Gwangju Institute of Science and Technology, Gwangju, Kora, 18-22 July 2010, 8 pg.

[HAR-11] Carl R. Hart, Siu-Kit Lau, Active noise control with linear control source and sensor arrays for a noise barrier, Journal of Sound and Vibration, Elsevier Ltd, 15-26 pg

[SAL-15] D. Saliunas, V. Volkovas, Investigation of noise barriers enhancement efficiency for attenuation of low frequency traffic noise, Mechanika Volume 21(1), ISSN 1392-120, 2015, Accepted February 02, 2015, 56-63 pg.

[SIS-12] Agustín E. Sisamón, Silja C. Beck, Adrián P. Cisilinoa, Sabine LANGERB, Asociación Argentina de Mecánica Computacional Vol XXXI; Salta, Argentina, 13-16 November 2012, 3265-3283 pg.

[KRI-10] Ulf R. Kristiansen, Erlend M. Viggen, Computational methods in acoustics, Department of electronics and telecommunications, NTNU, 2010, 69 pg.

[FAU-02] Nicolae FAUR, Elemente finite fundamente, Editura Politehnica, ISBN, 973-8247-98-5; Timisoara, Romania, 2002, 230 pg.

[STR -13] Florina Anca Stremtan, Cercetari privind modelarea, simularea si dezvoltarea materialelor acustice, UTCN, Cluj-Napoca, Romania, 2013, 181 pg.

Analiza influenței barierelor de zgomot asupra surselor liniare

Rezumat: *Această lucrare îşi propune cuantificarea teoretică a influenței barierelor de zgomot montate dea lungul surselor liniare. În acest scop au fost analizate patru tipuri de bariere cu înălțimi de doi metri, comparând totodată influenta structurilor fonoabsorbante, în cazul montării acestor structurii pe suprafața barierei aflată în vecinătatea frontului de undă incident. Astfel, analiza stării acustice a fost realizată la frecvențele de 100, 150 şi respectiv 250 Hz. Coeficienții fonoabsorbanți ai structurilor fonoabsorbante sunt de 0,2, pentru frecvența de 100Hz şi 0,5 pentru frecvențele de 150 şi 250Hz.*

Alin Cosmin TOT, PhD Student, Department of Mechanical Engineering Systems, Technical University of Cluj-Napoca, e-mail: tot.alin.cosmin@gmail.com, Romania

Mariana ARGHIR, Prof. Dr. Eng Department of Mechanical Engineering Systems, Technical University of Cluj-Napoca, e-mail: Mariana.Arghir@mep.utcluj.ro, Tel.: (+)0264.401.657, Romania