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The Influence of the Coefficient of Acoustic Absorption of the Facades of the Buildings from the Street Profiles on the Noise Level from the Urban Road Traffic

ABSTRACT

Considering the design of the urban assemblies from the point of view of the acoustic protection, in order to obtain an urban noise level that has values that fall within the provisions specified in the technical regulations in force, regarding building acoustics and urban acoustics, for the configuration of the transverse profiles of the traffic arteries bordered with buildings, a special importance also has the judicious design of the building fronts facade construction elements, because by the values of the acoustic absorption coefficients of the materials/products of the facades of the buildings that border the cross-sectional profiles, the value of the noise level from the urban road traffic, can be influenced as it is received at the receiver. In the case of the design from the point of view of the urban acoustics of the facade elements of the buildings that border the transverse profiles of the traffic roads, the establishment of the use for finishing of some types of construction materials/products, is made according to their acoustic absorption characteristics, so as to obtain a diminution of the propagation by reflection, between the fronts of buildings, of the urban noise coming from a source of traffic, to the receiver situated in the building or in the external environment, in a point of the transverse profile of the traffic artery. The method of calculating the street noise level, at one point, is very complex and contains a multitude of variable parameters of the street profile. There were made researches by calculation studies regarding the values of the equivalent noise level, Lext (f), from traffic, - which were performed for a street-study profile, considered as a standard, then for 6 cases of study-road profiles. It was shown that for a traffic lane of technical class 1 (with 8 lanes of traffic), bordered by two fronts of buildings of at least 8 floors high, paved with asphalt, without trees and with a complex composition of traffic, indicates that values of transmission noise can be diminished up to 15 dB, from 69 dB (A) to values of 84 dB (A), depending on the types of absorbing materials used to finish the facade walls of the buildings that border the transverse road profiles.

Keywords: acoustics, civil, buildings, facades walls, urban noise, absorption coefficients
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Introduction

Considering the design of the urban assemblies from the point of view of the acoustic protection, in order to obtain an urban noise level that has values that fall within the provisions specified in the technical regulations in force, regarding building acoustics and urban acoustics, for the configuration of the transverse profiles of the traffic arteries bordered with buildings, a special importance also has the judicious design of the building fronts facade construction elements, because by the values of the acoustic absorption coefficients of the materials / products of the facades of the buildings that border the cross-sectional profiles, the value of the noise level from the urban road traffic, can be influenced as it is received at the receiver.

Literature Review

Considering the regulations and norms for noise in urban areas, in many European countries in urban areas, traffic arteries are bordered by acoustic screens made of structures (materials / products) of buildings that have the role of absorbing noise from road traffic, and the facades of building boundaries delimiting traffic arteries are designed, both geometrically and in terms of finishes, so as to avoid the phenomenon of reflection, between the facades of buildings, waves of traffic noise, in the case of a cross street profile. Also, in our country, Romania, acoustic screens are provided but only locally, in few of the urban areas that delimit highways from rural localities mainly, and there are several ongoing projects that provide acoustic screens in some urban areas for delimiting railways from civil buildings that border these arteries railway traffic.

Methodology

In the case of the design from the point of view of the urban acoustics of the facade elements of the buildings that border the transverse profiles of the traffic roads, the establishment of the use for finishing of some specific types of construction materials/products is made according to their acoustic absorption characteristics, - respectively of the coefficient of acoustic absorption -, so as to obtain a diminution of the propagation by reflection, between the fronts of buildings, of the urban noise coming from a source of traffic, to the receiver situated in the building or in the external environment, in a point of the transverse profile of the traffic artery.

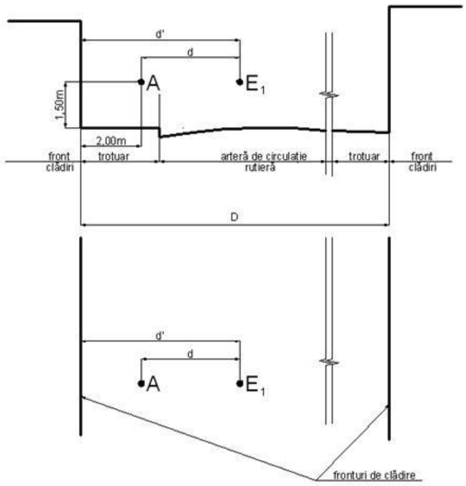
In Romania there is a method of calculation the street noise level, at one point from a transverse profile of the traffic artery, specified in norm C125:2013 “Normative regarding Acoustics in constructions and urban areas”, Part IV “Noise protection measures in urban areas”.

The method of calculating the street noise level, at one point, "L_I^A", is very complex and contains a multitude of variable parameters of the street profile, such as: distances between buildings delimiters from the two sides of the road, also the height of buildings delimiters, types of facades of the buildings, traffic regime, traffic components (numbers and types of cars, buses etc.), types of road surface materials, types of green spaces, etc., among which one parameter depends on the average acoustic absorption coefficients of the facades of the delimiting buildings, and finally all this variables are influencing the final value of noise level.

Level of noise in measurement point "A", Lext(f), originated from several types of vehicles moving on multiple lane of an thoroughfares is in formula:

$$L_{ext}(f) = 10\ \lg \left(\frac{1}{T} \sum_{I=1}^{n} t_I \cdot 10^{\frac{L_I^A}{10}} \right) \quad \text{(dB)}$$

Figure 1. *Geometrical Elements for Determining the Noise Level, "L_I^A",*



in which:
A - measurement point (situated usualy at 2,00 m distance from the building facade and at 1,50 m high distance from the ground);
d - distance from noise source to the measurement point, (m);
d' - distance from noise source to the building facade, beside it is made the measurement, (m);
D - distance between the buildings fronts, (m);
E1 - source of noise.

The level of noise in measurement point "A", "L_I^A", originated from a noise source type "I", in case of an thoroughfares which is bourded with two fronts of buildings, is calculated with the following formula:

$$L_I^A = L_I^1 + 10\lg\left\{ \frac{1}{\left[\left(\frac{d}{d_0}\right)^{\frac{k}{10}}\right] c_s c_{zv}} + \frac{1}{\left(\frac{d'-d}{d_0}\right)^{\frac{k'}{10}}} \left[\frac{1-\alpha_1}{\left(\frac{d'}{d_0}\right)^{\frac{k}{10}}} + \frac{\frac{(1-\alpha_1)(1-\alpha_2)}{c_s c_{zv}}}{\left(\frac{D-d'}{d_0}\right)^{\frac{k}{10}} \left(\frac{D}{d_0}\right)^{\frac{k'}{10}}} \right] \frac{\left(\frac{D}{d_0}\right)^{\frac{k'}{5}}}{\left[\left(\frac{D}{d_0}\right)^{\frac{k'}{5}} - (1-\alpha_1)(1-\alpha_2)\right] c_s c_{zv}} \right\} \quad \text{(dB)}$$

in which:

D, d, d' – *have the semnification from fig. 1;*

$d_0 = 1,00\ m$;

k - *souce directivity coeficient; corresponds to the direct waves propagation from the source to the measurement point; direction of waves is considered perpendicular to the front of buildings;*
- $k = 20$, *for a spherical source (eg a car)*
- $k = 10$, *for a cylindrical linear source (eg road traffic typical)*
- $k = 0$, *for parallel linear sources (eg traffic stream, is unreal situation)*

k' - *directivity factor for reflected waves between the fronts of buildings.*
- $k' = 10$, *on thoroughfares lined by a single front of buildings;*
- $k' = 5$, *For two fronts with more than 4 floors;*
- $k' = 3$, *For two fronts max. 4 storey buildings on one side and 4 … 8 floors on the other side;*
- $k' = 0$, *in two fronts of buildings with 8 floors.*

α_1 - *sound absorption coefficient of building facades placed on the thoroughfares where is the point of measurement;*

α_2 - *sound absorption coefficient of the facades of buildings located on the thoroughfare opposite part from where is the point of measurement.*

Sound absorption coefficient, **"α_i"**, *depends on the composition of the facade, represented by the coefficient* **"φ"**:
- $\varphi = 1$ *- for plane facades;*
- $\varphi = 1,1$ *- for facades with balconies continue;*
- $\varphi = 1,2$ *– for facades provided with continuous logy balconies.*

Sound absorption coefficient, "α_i", corespond to the area **"S_i"** *realized from material "i" on the facade.*

Area **"S_A^I"** *from the fronts of buildings, correspomnding to the measurement point "A", composed by* **"n"** *different acoustics areas, "S_i".*

$$S_A^I = L \cdot H = L \cdot 2h \qquad (m^2)$$

where: $L = 20m$;

$H = 2h$, *iar* $h =$ *height characteristic of transporting vehicle considered, "T".*

$$S_A^I = \sum_{i=1}^{n} S_i^j = L \cdot 2\,h \quad (m^2)\ , \qquad \alpha_j = \frac{\varphi_j \sum_{i=1}^{n} (\alpha_i^j \cdot S_i^j)}{S_A^I}$$

where: $j = 1,2$ *(coresponding for delimiters buildings fronts).*

c_{zv} - *sound absorption coefficient corresponding to influence of existing green areas*

c_s - *sound absorption coefficient corresponding to the surface structure of the road surface (road surfacing).*

To show the influence of specific types of materials/products finishing a building façade, concerning the transmission to the receiver, of urban road traffic noise, for each case study-profile-street analyzed, there were considered in the calculation buildings with surfaces façade, related to traffic means of transport considered, finished with one particular type of material/product finishing, with sound absorption coefficients, "$\alpha_i(f)$", specific.

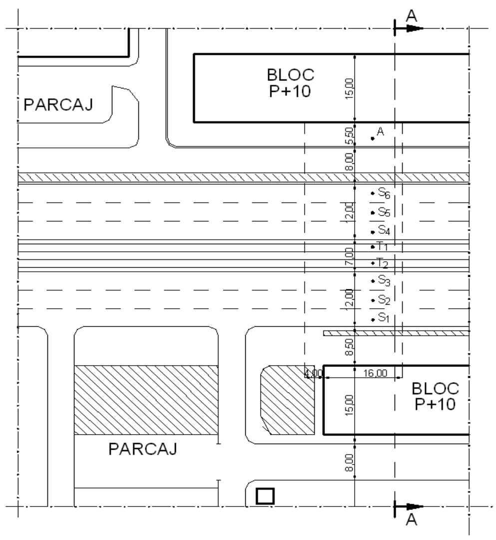
Researches were performed by analyzing the sound absorption properties, for 6 types of structures (materials / products) of constructions that can be used to finish the facades of buildings.

For the beginning it was chosen a *street-study profile*, considered as the *standard profile*, (Case Etalon), representing a technical class 1 traffic artery, bordered by two building fronts, having minimum 8 floors high, having the following characteristics:
- The geometric characteristics according to Figure 5 and Table 1.

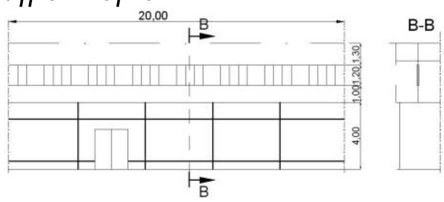
Table 1. *Distances and Positions of Noise Sources*

Distance (m)	Position of the noice source							
	S_1	S_2	S_3	T_1	T_2	S_4	S_5	S_6
d	40,40	36,40	32,40	28,65	25,40	21,40	17,40	13,40
d'	42,40	38,40	34,40	30,65	27,15	23,40	19,40	15,40
D				54,0				

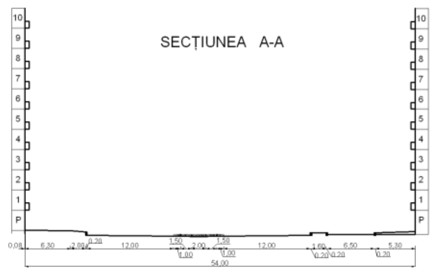
Figure 5. *Geometrical Characteristics of Traffic Profile*



Plan



Front building area **„S "**



Transversal section A - A

- Front building area, „S ", corresponding to measuring point "A", 20,00 meters in length, is composed of: single glazing, concrete parapet, double glazing (60% of the facade surface), flat surface of plastered and finished reinforced concrete (40% of the facade surface).
- The equivalent noise level from traffic was calculated, over a characteristic period T = 3600 s (between hours 14,00— 15,00) taking into account 4 tram routes and 2 bus routes.
- The acoustic parameters were:

a) c_s for asphalt = 0.9
b) c_{zv} for spaces without trees (n = 0) = 1.00
c) φ the coefficient that takes into account the composition of the facades, for flat facades, φ = 1.1

d) k = 10 for traffic (cylindrical source); k ’= 0 (for building fronts with min 8 floors)
e) calculation of the average sound absorption coefficients of the facades, α_1 and α_2.

Then it was made the definition of traffic: the number of means of traffic for a period of one hour "ni / h" and the time in which the vehicle crosses the distance of 20 m, "τi".

After that, it was calculated the specific noise level "L_i^A" for the different types of vehicles passing on the traffic artery and of the equivalent noise level L_{ext} (f).

The result of the noise level, at the measuring point "A", Lext (f), coming from all types of vehicles circulating on the 8 lanes of the traffic artery, is:

$$Lext\ (f) = 76\ dB\ (A)$$

To highlight only the influence of the noise absorption coefficients of the facades of the buildings that border the cross-sectional road profiles, on the noise level coming from the urban road traffic, in the researches carried out by calculation, for the specific situation considered of the street-study profile - there were made changes only of the values of the acoustic absorption coefficients, "$\alpha_i(f)$", considering by study variants (cases A to F) with several types of building materials / products for finishing the facades of buildings.

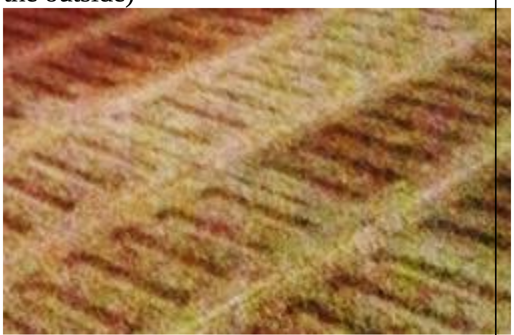
There were selected significant types of materials/products for finishing facades walls of buildings, then performing calculations for determining the level of noise from road traffic for a number of more specific situations - *street-profile trial* - analyzed.

There were studied cases A ... F, considering, both to the left and to the right of the front of buildings, facades finished with materials/products of various kinds, with sound absorption coefficients, " $\alpha_i(f)$ ", with values of: $\alpha_i(500) = 0,15$; $\alpha_i(500) = 0,12$; $\alpha_i(500) = 0,94$; $\alpha_i(500) = 0,03$; $\alpha_i(500) = 0,98$ şi $\alpha_i(500) = 0,02$.

Results

The results of studies contains the values of the parameters influences comparing the studied cases, Streets Profiles – Cases A … F, and are showing in Table 2:

Table 2. *Results of Noise level, at the Measuring Point "A", L_{ext} (f) for the Analyzed Cases*

Case	Type of façade considered	Sound absorption coefficients "α_i(500)",	Noise level, at the measuring point "A", L_{ext} (f)
Etalon	Finished facades composed of: single glazing, concrete parapet, double glazing (60% of the facade surface), and the flat surface of plastered and finished reinforced concrete (40% of the facade surface).	0,03 ; 0,02 ; 0,15 (60%) and 0,03 (40%)	L_{ext} (f) = 76 dB(A)
A	Curtain wall facades, glass finishes (double glazing)	0,15	L_{ext}(f)=75,7≈76dB(A)
B	Facades finished with thermal insulating decorative panels, made of rigid polyurethane (PUR) foam, with a stone-like surface texture 	0,12	L_{ext}(f) = 78 dB(A)
C	Finished facades with concrete surfaces covered with sound-absorbing structure (made of basalt mineral wool + conglomerate boards of wood chips, on the outside) 	0,85	L_{ext}(f)=69,1≈69dB(A).
D	Facades finished with plaster of min. 20 mm, applied in two layers (primer + plaster), on any support surface, painted in water colors	0,03	L_{ext}(f) = 82 dB(A)
E	Facades finished with soundproofing panels with sheet metal faces with holes	0,98	L_{ext}(f)=69,0≈69dB(A).

			
F	Facades finished with marble (or glazed ceramic tiles)	0,02	L_{ext}(f)=84,2≈84 dB(A)

Discussion and Conclusions

After studying acoustic calculations, concerning the equivalent noise level values, in the measuring point "A", L_{ext}(f), originated from traffic, - that have been made for a *street-study profile,* considered as the *standard profile,* (Case Etalon), then for *6 street-profile cases study* -, reveals that for a traffic artery technical class 1 (with 8 lanes), bounded by two fronts least 8 stories high buildings, paved with asphalt, without trees and a complex composition traffic (7 types of traffic means of transport) -, can be obtained *values that differ by up to 15 dB*, from *69 dB(A)* to a value of *84 dB(A)*, depending on the types of materials/products construction (respectively with specific sound absorption coefficients thereof) used for finishing facade walls of the buildings that border the transversal street profiles.

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