Approaches to classification of urban areas in relation to transport noise impact

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Introduction

It is only possible to control the acoustic climate of urban environments if acoustic factors at work in open spaces or built-up areas are fully known and explored.

The effect of mutual interference of attenuation, reflection and diffraction of acoustic waves around urban structures conditions the acoustic climate in built-up areas that are situated near noise sources as well as in the adjacent areas.

The distribution of the acoustic field that results from the cumulative effect of these factors is usually presented on acoustic maps as lines connecting points of equal levels of noise (isolines). However, not only noise-related issues but also features of the urban building layout or geometry of streets have an impact on the contours and the distribution of isolines. Apart from the distance and changes in the cross-section of streets and squares, buildings, their location and form are the basic urban factors that influence the acoustic climate of cities.

Literature does not provide any elaboration on the relationship between the acoustic field generated by road transport and the structure of a given built-up area, while the percentage of a built-up area or its length are the elements usually considered in the investigations on the subject. The canyon built-up area (U) and the one-sided built-up area (L) are usually the only types of urban structures defined in acoustic relevant classifications. Other classifications are even more general: detached house, grouped houses, terraced house, buildings in scattered formation, buildings in close block [1], [2].

It is therefore requisite to determine a more accurate classification of urban space and the mutual relationship between the urban structure and acoustic conditions. Furthermore, each urban structure usually offers a body of information on a possible number of inhabitants in a given region of the city. If all these elements are connected, it will be possible to provide some guidelines used in designing new urban structures or in restructuring and renovating the existing ones.

Changes in urban infrastructure and land development have been brought about by the ways in which buildings were constructed and by different forms of the activity of the population. A number of greatly simplified, basic types of urban built-up areas in European cities can be distinguished: medieval urban space, which usually constitutes the historical city centre, with restricted access of urban transport; classical urban space; Haussmann's urban space; modern urban space, usually concentrated in the city outskirts. The great diversity (location of buildings; distance between buildings) of built-up areas significantly hinders their systematic classification [3].

Depending on the manner of the propagation of acoustic waves, urban infrastructure can be defined as open or closed, with streets and squares as its basic components. Basic geometric parameters of streets or squares, such as their width and length, as well as the height, width and length of buildings, and the surface of the built-up area and the degree of openness [4], [5] are usually considered in traditional acoustic analyses. Modern approaches to the issue also include elements of the third dimension, for instance area roughness [3].

Research methods

Two basic research methods will be used to offer solutions to this problem: the measurement method (in actual urban structures) and the calculation method (computer simulations of designed structures).

The former, commonly used, usually does not provide too many findings on the relationship between the structure and the acoustic field, and merely offers an estimation of the acoustic conditions of a given district, region, street or building structure.

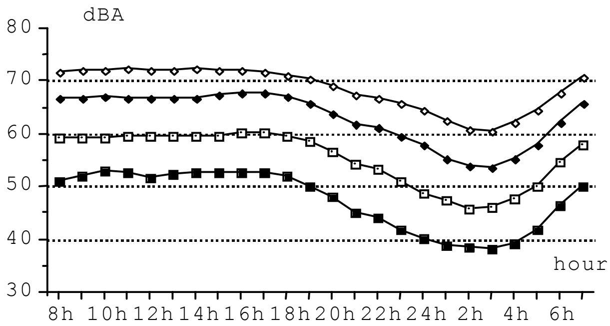
Both methods have been developed over the last few years at the l'INRETS and the Technical University of Lodz (Poland) in order to enhance scientific knowledge on mutual interconnections between urban geometry and the acoustic field.

Measurement method

Studies conducted using the measurement method in France were discussed in [2] in connexion with approximately four hundred 24-hour noise recordings made in a wide variety of urban and rural situations [6]. Some results obtained by applying data analysis techniques (factorial analysis, clustering) to the noise survey carried out were presented. The recordings were subsequently re-grouped into four sub-classes, the data processing yielded contrasted specific urban features coming from a "mixture" of city size, building type and street type considered as descriptive urban variables (Fig. 1).

Simulation method

Contemporary simulation techniques increase the scope of the analysis of divergent urban structures. For a more in-depth discussion on the problem see [7], [8], [9]. A virtual site was constructed for the purposes of these studies. The underlying construction principles, similar to the way in which Lego blocs are put together, make it possible to provide calculations for different urban situations (streets „L" and „U" and other combinations). Simulation calculations were also carried out for a fully built-up area (100%, which in this case corresponds to the "U" canyon street type) and an area without buildings (0%). They were extreme variants, used in the comparative analysis. Apart from the arterial road, geometric parameters and motor vehicle loads of the streets in all types of built-up areas did not change. Three geometric variants of the arterial road were analysed (street width: 20, 30, 50 m), while vehicle traffic load was constant (Table 1 and Table 2).



◇ continuous buildings, Paris city, charged street

♦ continuous buildings, Paris city, charged and mean street

□ detached buildings, quiet street

■ quiet street, individual houses, rural area

Figure 1: Average 24h exposures (hourly Leq) and the four clusters.

	„50"	„30"	„20"
0%	**0**	+1 dB	+2 dB
L	+1 dB	+2 dB	+3 dB

Table 1: Influence of "L" built-up area and street width on noise level. Comparison to variant 0% - „50"

	„50"	„30"	„20"
U (100%)	**0**	+1 dB	+2 dB
L	-1 dB	0	+1 dB

Table 2: Influence of "L" built-up area and street width on noise level. Comparison to variant U (100%) – „50"

Discussion

The main objective of this study was to explore the influence of the urban built-up layout on the formation and distribution of the acoustic field in urbanised areas. Both geometry of streets and selected building locations were given primary importance, and as many as 60 different geometric variants of the virtual site were subsequently examined [7].

The analysis of the urban acoustic field shows a significant relationship between the distribution of acoustic energy and urban morphology. While the influence of the street width yields the difference of about 1 dB in the cases considered, the influence of the geometry of the type of the building layout on the acoustic comfort is much greater, and ranges between 2, 3 or even 5 dB on facades for different building layouts. Such significant differences clearly indicate the need for a more rational urban design that would account for all elements of street geometry and that would necessarily be accompanied by an analysis of the acoustic field at each stage of the design process.

A seemingly small difference of 1 dB between individual variants of the geometry of streets or the geometry of the built-up area recorded in the calculations may result in the category change in the relative classification of urban space, and the difference of 2 – 3 dB may bring about radical changes in the classification. An area, for instance, may consequently be re-classed and moved from the category of "quiet" to "loud."

Conclusions

Classification of the urban space may in the future facilitate its assessment in terms of acoustic conditions;

Both measurement and simulation methods allow for the creation of such a classification;

Because of a high number of factors influencing the acoustic climate of the city, both geometric and physical, it is necessary to support the creation of such a classification with statistical methods.

References

[1] Stapelfeldt H.: Noise mapping for large urban areas. Proceeding of Inter.noise. Hague. Holland. 2001,5-18.

[2] Maurin M., Olivier D., At I. : Environmental noise levels and data analysis, Proc. I.O.A. vol 15 Part 3, 1993.

[3] Raimbault M.: Simulation des ambiances sonores urbaines: Intégration des aspects qualitatifs., Thèse de Doctorat de l'Université de Nantes – Ecole Polytechnique. France. 2002.

[4] Stawicka-Walkowska M.: Acoustics factor in town planning, (in Polish), ITB, Warsaw, Poland. 1988.

[5] Stawicka Walkowska M., Rudno-Rudzinska B.: Forming of housing estates as way of prevention against out door noise, (in Polish), ITB, Warsaw. Poland. 2000.

[6] Maurin M., Lambert J. : Exposure of the French population to transport noise, Noise Control Engineering Journal, vol 35 n° 1, 1990.

[7] Lebiedowska B.: Impact of transport noise in relation to urban planning, Report INRETS_LTE 0313, France.2003.

[8] Lebiedowska B., Beaumont J.: Urban transportation noise and the acoustic field of highly urbanised areas, IX Conference of Science and Technology: Building Physics in Theory and Practice, Lodz. Poland. 2003,412-421.

[9] Lebiedowska B., Beaumont J.: Impact of transport noise in relation to urban planning - Case study, 1st International Scientific Symposium, Environment & Transport, Avignon, France, 2003, 210-215.