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2013 | INNSBRUCK | AUSTRIA
15.-18. SEPTEMBER 2013
NOISE CONTROL FOR QUALITY OF LIFE

Acoustic characterization of pedestrian areas

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ABSTRACT

Many of the actions that have been proposed to revitalize tourism projects have not taken into account the environmental context and urban heritage in which they have to be developed, threatening the viability of it. One element often overlooked is related to acoustics and how it affects the city and citizens.

Our experience allows us to show that these areas with many different noise sources are being subjected to high noise levels. This could lead to social and structural deterioration of these surroundings often characterized as pedestrian areas.

Moreover, European Directive 2002/49/EC notes Strategic Noise Maps as a tool for designing action plans against noise pollution, collecting information from road traffic, railway, aircraft and industrial noise. However, pedestrian areas are not taken into account for this study, and, judging by the number of complaints we should consider them as a major source of noise pollution.

We propose the development of a project focused on the study of noise impact in an urban pedestrian area like the one in León (Spain). This will let us set out the foundation of sources found in pedestrian areas, which will help to establish a proper methodology for its analysis as part of noise maps.

Keywords: urban noise, pedestrian areas, urban planning

1. INTRODUCTION

The Environment Agency of the European Commission noted that annual economic losses in the EU induced by noise in 2001 were between 13,000 and 38,000 million €. These phenomena have been studied from different international research that have agreed to note, as indicated by some authors [1] that the acoustic comfort is one of the main factors in determining the quality of public spaces.

In Spain is easy to see much of the heritage of the city, which is a tourist attraction, is located in urban pedestrian areas. That is the case of the city of León, where the Cathedral with its magnificent stained glass windows, the house called "Botines" from Gaudí, among other examples, are attractors for tourism development, and therefore for the economy of these places. The enhancement of areas related with tourism activities and entertainment, including shops, bars, pubs, and the existence of

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numerous schools and recreational areas, has resulted in significant levels of noise pollution, having a negative impact in this area.

Directive on Environmental Noise (END) [2] does not require the inclusion of pedestrian areas as specific areas of study regarding to noise. This fact goes against the enhancement of it as nodes of tourist-heritage development. If these areas were included in the environmental study, they could improve in different ways: urban, constructive and / or legal if necessary.

2. METHODOLOGY

2.1 Pedestrian Areas

Due to the presence of numerous noise sources in pedestrian areas [3, 4, 5], studies that have been carried out in pedestrian areas have been done through measurements [6]. Furthermore, simulation programs do not directly give results on the analysis of these areas.

We consider these areas as very important areas related to noise annoyance, at least in our city. We can see that although it is not a very large area and not very populated (~4% of the total population of the city), the number of complaints respect to the whole city is significant.

Figure 1 – This is a caption for the figure

2.2 Case Study: the City of León, Spain

Leon is a city located in northwestern Spain. It has an area of 37 km^2 and 131,680 inhabitants, according to data from 2012.

The pedestrian area of the city has 5,162 inhabitants with a density of 11,6 inhabitants/km^2, that makes the 3.9% of the total population of León. It has an area of 0,44 km^2, equivalent to 1.14% of the territory.

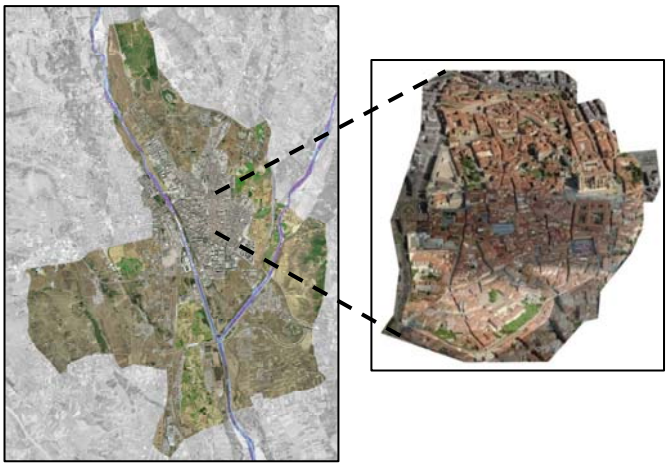

Figure 2 – City of León and the pedestrian area

In summary, we could point out that in the pedestrian area of the city of Leon, converge factors as:

- The population drop and the proliferation of substandard housing.
- The decline of traditional activities located in the area.

• The aging of the population.
• The low maintenance of the area and the significant environmental damage.
• Noise pollution due to the presence of numerous pubs and bars, shops, schools, tourist areas, etc.

Despite these problems we must not forget that the object of our study area has major tourist attractions and could be a residential claim again, being this part of the city oldest one, with a special charm. These qualities make it a space with great potential. In this sense we note that:

• It is the symbol of León. It has the main architectural and urban heritage, (the Cathedral, the Basilica of St. Isidore, Gaudi's Building "Botines House", etc.)
• Its transformation into a pedestrian area was a great benefit for the population of the city. It also facilitated Leon heritage conservation, and at the same time served as a tourist attraction.
• It is a multifunctional space in the center of the city.
• Meets most cultural facilities in the city. In recent years, León has strengthened here many socio-cultural facilities through the rehabilitation of some buildings with historical value.
• The existing redevelopment projects will allow the consolidation as an important commercial area of the ancient city.
• Is a large settlement with all types of catering establishments, where tourists and inhabitants like to go and enjoy the atmosphere, mainly on summer.

We can't forget that in 2006, due to numerous complaints from neighbors, the city of León stated this area as Acoustically Saturated [7]. This study implies a number of measures such as restricting the number of bars, the timetable of the delivery services and the garbage collection, among others.

2.3 Classification as an urban network

To this end, we have proposed a categorization for noise analysis found in that area through the classification of existing roads and plazas and its operation as a small urban network. This urban network is based on the *Principles of Urban Structure* by Salingaros [8]. This structure will help us to establish a behavior of the area without requiring infinite measures.

An urban network is connected in many ways, self-organizing, so that the position of nodes and connections will result in an organized complexity that help us to understand the area from the acoustic point of view.

Table 1 – Urban Network Classification

Node	Concentration areas due to the presence of recreational places, singular buildings, stores, among others. Its activity varies depending on the day and time, although the most active nodes are in the night time
Access	Roadways in and out of the area (pedestrian and vehicular). The use varies depending on the day and time
Main connector	Pathways that work as a connection between places with great flow
Secondary connector	Connection tracks that work as distribution to areas of interest
Sporadic connector	Pathways whose function is to connect occasionally other routes or nodes with greater activity
Complementary routes	Pathways exclusively for the residents of the area, which complement the urban network
Unused routes	Pathways that due to their nature and location, are not used as part of the urban network

2.4 Preliminary Analysis

This first analysis took into account the differences in the behavior of the area for the different days of the week, categorizing them according to their performance within the urban network. After

numerous observations and analysis, the streets were classified according to their characteristics in the three slots (day, evening and night) over different days of the week.

Table 2 – Classification through the week due to their activities

Period of time	Day						
	M	T	W	X	F	Sa	Su
Day	- Influx of people due to the presence of stores and working places, tourism... - Presence of schools - Vehicle access for delivery and neighbors					- Influx of people due to the presence of stores, tourism... - Vehicle access for neighbors - Leisure area	
Evening	- Presence of entertainment places like cafeterias and bars - Influx of people entering and leaving the area			- Presence of entertainment places like bars and cafeterias that highlight its activity these days - Influx of people entering and leaving the area			
Night	- A few streets with nightlife activity			- Nightlife activity - Streets that works as connectors and distributors to areas with higher concentration of nightlife activity - Influx of people entering and leaving the area			

Once we had this urban classification, we represent this network through a series of maps that could reflect the different situations we have encountered during the different days of the week. We established a color coding that would respond to different uses.

Table 3 – Color codification - Urban network classification

	Node
	Access
	Main connector
	Secondary connector
	Sporadic connector
	Complementary routes
	Unused routes

We registered 9 schools, more than 170 stores, 135 bars and cafeterias during the evening period, 45 bars and pubs, and 145 restaurants, bars and cafeterias that open during the day time, especially in the weekends.

The next two figures shows the difference between the two sections that we can found in a week depending on the activities performed in the night period: from Sunday to Wednesday and the second one from Thursday to Saturday. In the first one we can observe that there are a few bars that open till

late. In this case, most of the streets are complementary or unused routes. On the other hand, the second figure reflects the activity on Thursday, Friday and Saturday. We can see that many streets work as nodes and main connectors due to the presence of numerous bars and pubs.

Figure 3 – Urban network classification due to its activity, during the night period: from Sunday to Wednesday

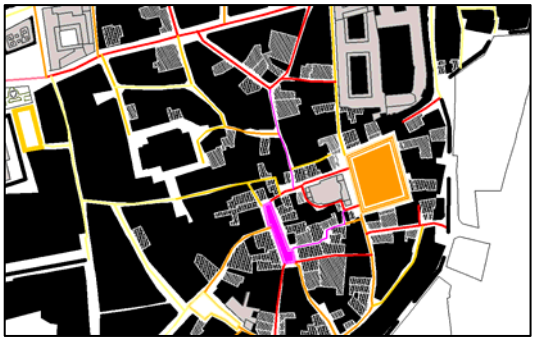

Figure 4 – Urban network classification due to its activity, during the night period: from Thursday to Saturday.

2.5 Measurements and urban network classification

The next step was the establishment of a correlation between the urban network classification and the noise levels we would find in those areas. That way we can guarantee that the data collected during the observations we made about the operation of the area is correct.

In these measurements we guarantee the diversity in terms of configuration and its main activity, so, although they were within the same classification, its performance was different. A total of 98 measurements that lasted 10 minutes, with a microphone height of 1.50 m.

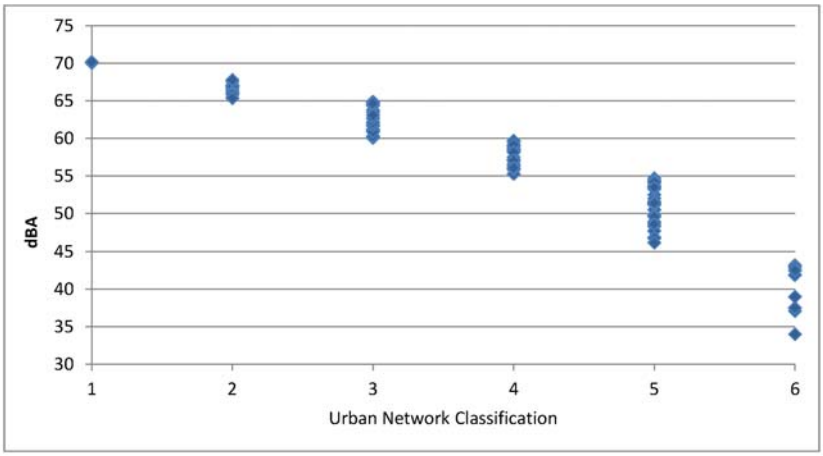

Figure 5 – Short term measurments and urban network classification

Table 4 – Average measurements made in each category

Type	1	2	3	4	5	6
LAeq (dBA)	70,2	66,7	62,5	57,8	51,4	39,8

The next step was to establish a correlation between the urban noise levels found in the pedestrian area with the classification done as an urban network. This way we could resemble the data collected in urban analysis with noise levels, and thereby, ensure that a certain behavior of the area is related to certain noise levels.

Table 5 – Urban network classification due to the noise levels

Type	**Levels (dBA)**	**Urban network classification**
1	>70	Node (nightlife)
2	65 - 70	Main connector and principal access
3	60 - 65	Secondary connector and secondary access
4	55 - 60	Sporadic connector and access
5	45 - 55	Complementary routes
6	<45	Unused routes

Now we have the classification with the noise levels and the average value of each category, to introduce the information and model the strategic noise map of this area, is necessary a single value for the different time periods.

$$Ldweek = 10\lg\frac{1}{7}\left(5*10^{(Ld_1/10)} + 2*10^{(Ld_2/10)}\right) \quad (1)$$

$$Leweek = 10\lg\frac{1}{7}\left(3*10^{(Le_1/10)} + 4*10^{(Le_2/10)}\right) \quad (2)$$

$$Lnweek = 10\lg\frac{1}{7}\left(4*10^{(Ln_1/10)} + 3*10^{(Ln_2/10)}\right) \quad (3)$$

Table 6 – Week division based on activities

Ld_1	Monday to Friday	Ld_2	Saturday and Sunday
Le_1	Monday to Wednesday	Le_2	Thursday to Sunday
Ln_1	Sunday to Wednesady	Ln_2	Thursday to Saturday

2.6 Final analysis

As a final analysis, we made week measurements at three different points placing the microphone in the balconies of the dwellings. That way we can measure the noise levels during a whole a week and compare them with the urban network classification and the strategic noise map levels.

Table 7 – Comparison between urban network classification - long term measurements - strategic noise map

Dwelling 1			
Time period	**Urban network classification**	**Long term measurements LAeq (dBA)**	**Strategic noise map**
Lweek		59,3	58,0
Ld	3 (60-65)	60,6	60,0
Ld_1	4 (55-60)	58,9	
Ld_2	3 (60-65)	63,2	
Le	4 (55-60)	59,5	57,0
Le_1	5 (45-55)	54,3	
Le_2	4 (55-60)	61,3	
Ln	4 (55-60)	56,6	56,0
Ln_1	4 (55-60)	57,2	
Ln_2	4 (55-60)	55,7	
Dwelling 2			
Lweek		62,0	60,0
Ld	3 (60-65)	60,8	60,0
Ld_1	3 (60-65)	61,2	
Ld_2	3 (60-65)	59,3	
Le	2 (65-70)	65,3	64,0
Le_1	3 (60-65)	63,3	
Le_2	2 (65-70)	66,3	
Ln	3 (60-65)	62,0	60,0
Ln_1	4 (55-60)	57,2	
Ln_2	2 (65-70)	64,8	
Dwelling 3			
Lweek		58,5	57,0
Ld	3 (60-65)	60,2	59,0
Ld_1	3 (60-65)	60,8	
Ld_2	4 (55-60)	57,3	
Le	4 (55-60)	58,4	58,0
Le_1	4 (55-60)	57,2	
Le_2	4 (55-60)	59,1	
Ln	4 (55-60)	55,4	54,0
Ln_1	5 (45-55)	54,8	
Ln_2	4 (55-60)	56,0	

We can see that the results are within the different types of the urban network classification, except for dwelling 3, where a road street nearby could influence on the measurements.

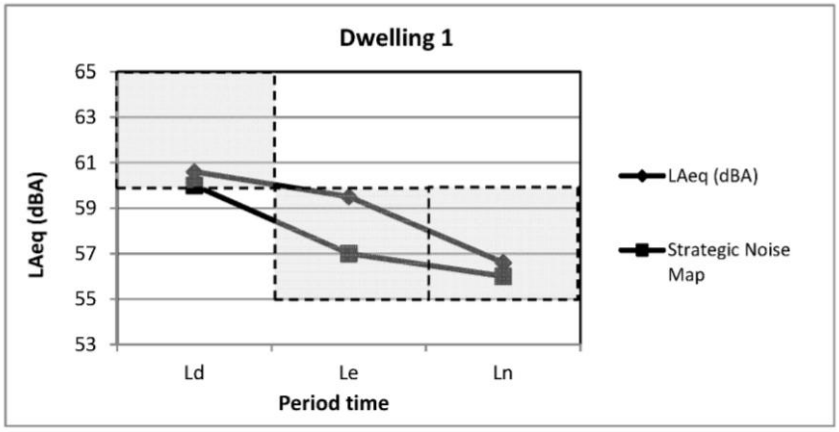

Figure 6 – Comparison between strategic noise maps values and long term measurements from dwelling 1

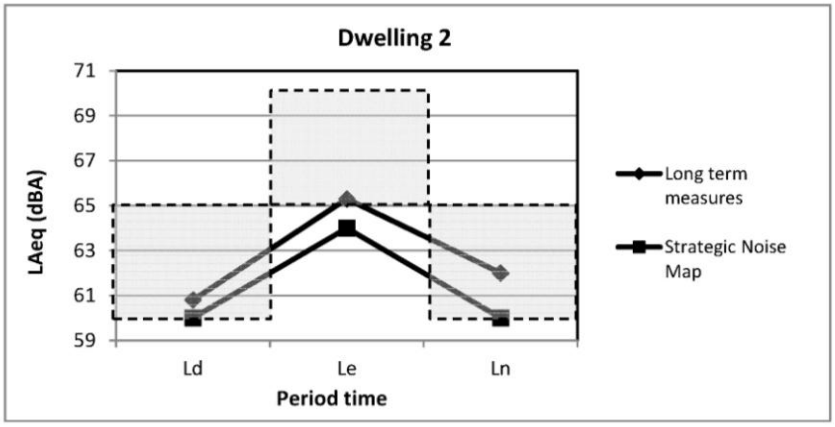

Figure 7 – Comparison between strategic noise maps values and long term measurements from dwelling 2

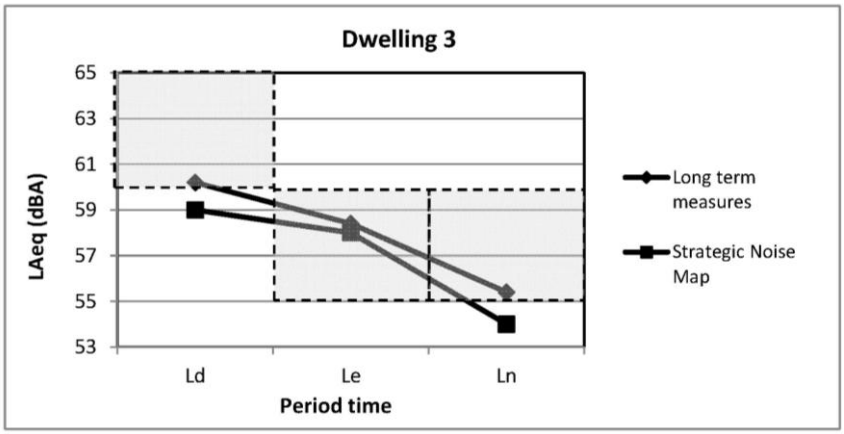

Figure 8 – Comparison between strategic noise maps values and long term measurements from dwelling 3

3. CONCLUSIONS

A classification based on the urban analysis is suitable for studying areas such as pedestrian zones. We should highlight that, based on this analysis and a number of short measures at strategic points, we

can assign a certain noise levels for that area. To do so, we must emphasize the need of a deep knowledge of the area to be studied in terms of its operation and the urban morphology of it.

This study will provide the basis for the study of pedestrian areas and include them in the strategic noise maps. That way, they will be part of the action plan against noise and will be take into account for urban and legal improvements, if necessary.

It is noteworthy that, the study of the 10.9 km. of streets and squares that make the pedestrian zone, in the night period from Sunday to Wednesday, 26,7% of them are exposed to noise levels above the specified in the national legislation regarding acoustic quality objectives applicable to residential areas [9]. This percentage goes up to 46,3% on Thursday, Friday and Saturday. For that reason, we think that its inclusion as part of the strategic noise map and the action plan is mandatory.

In this analysis we didn't take into account the annoyance, just the noise levels and its classification. Other series of analysis such as social surveys should be included as part of the methodology.

Different international researchers have agreed [1] that acoustic comfort is one of the main factors in determining the quality of public spaces. Acoustic saturation noise levels have become a way to qualify an environment or space as attractive or not. In this sense, the spaces acoustically saturated have been repudiated by residents, resulting in depopulation and abandonment [10, 11] that has contributed, in the case of areas of interest like the one in the city of León, to a decline the volume of visitors, but most important the number of residents.

ACKNOWLEDGEMENTS

To the City Council of León, especially to the Department of Environment, Sustainable Development and New Technologies and the neighbors of the historic city center of León.

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