ACOUSTIC IMPROVEMENT IN URBAN AREAS. THE CASE OF FLORENCE

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ABSTRACT
According to recent Italian regulations [1] concerning noise pollution control, each Municipality is bound to classify its territory into areas characterized by homogeneous acoustical features. Referring to statistic parameters, such as the densities of population and the human activities, and to the incidence of the traffic noise, it is possible to define a preliminary plan of acoustic zoning of the territory.
For every zone, maximum limits of environmental noise are defined by not to overcome, otherwise it is had to intervene with plan of acoustic improvement.
The measured acoustic climate in the city of Florence points out hat a lot of areas of the historical centre need interventions with the purpose to reduce the levels of noise in the limits attributed to every area.
In this paper a general procedure based on the above-mentioned concepts, is presented, together with an example of application for the town of Florence, and some typical examples of acoustic improvement for a plaza and an avenue.

IDENTIFICATION OF THE ACOUSTICALLY HOMOGENEOUS AREAS

According to the Italian Law for noise pollution control [1], each Municipality is bound to classify its territory into homogeneous areas and to define for each of them the limiting values of continuous equivalent sound pressure levels (table 1).

Table 1: noise limits for acoustically homogeneous areas, according to the Italian Law.

Acoustical class	Description	Noise limits dB(A) day	night
I	Particularly protected areas (hospitals, schools, parks, rural residences, etc.)	50	40
II	Mainly residential areas (local traffic, low density of population and commercial activities, no artisan activities and factories)	55	45
III	Residential mixed areas (town traffic, middle density of population, low density of artisan activities and offices, no factories)	60	50
IV	Very busy areas (intense traffic, areas closed to motorways, high density of population, offices and presence of small factories)	65	55
V	Mainly industrial areas (low density of population)	70	60
VI	Exclusivity industrial areas (no resident population)	70	70

The identification of the first, fifth and sixth classes can be carried out by the analysis of Urban Development Planning. The problem is to identify the remaining homogeneous areas (second, third and fourth classes), according to an objective analysis.
Each parameter is associated to an index (Ip, Im and Ic), which can vary from 1 to 3, according to the value of the related parameter itself. Limiting values between the classes of low, medium and high density are derived from a statistical percentile algorithm; zero values for indexes can be assigned to classes of density lower than a suitable threshold. As a further step, for each census division, a synthetic index I_{tot} can be derived as weighted sum of the above-described indexes. In the case of the Florence Municipality, the value of zero has been assigned to classes of density less than 10 inhabitants/km^2 for population parameter, less than 3 activities/km^2 for commercial and manufacturing activities. Weighting factors were obtained through a statistical analysis, which evaluates the contribution of the parameters Ip, Im and Ic to noise annoyance as follows:

$$I_{tot} = 1{,}00*Ip + 1{,}15*Ic + 1{,}30*Im$$

Table 2: synthetic index values for different acoustical classes	
I_{tot}	Acoustical class
3	II
4,5 e 6	III
>6	IV

The value of I_{tot} has been linked to the acoustical class referring to sample areas exhibiting incontrovertible features (table 2).
This way it has been possible to create a database which contains, for each census division, all statistical data, related indexes and acoustical class [2, 3].

ACQUISITION AND ELABORATION OF STATISTICAL DATA

The idea of classifying the acoustical features of territory by means of statistical parameters comes from the concept that noise pollution in a given area is closely linked to density of population, railway and road traffic lines and human activities. Fur this purpose, the following statistical data can be collected fur each census division [4]:
- census of population;
- census of manufacturing activities;
- census of commercial activities;
- census of traffic intensity.

From these data, it is possible to work out, fur each census division, the statistical parameters shown in table 3.

Table 3: statistical parameters and indexes for census data evaluation					
Statistic parameter	Unit	Index	Classes of Density Low	medium	high
Density of population	(inhabitants/km^2)	Ip	1	2	3
Density of manufacturing activities	(Activities/km^2)	Im	1	2	3
Density of commercial activities	(Activities/km^2)	Ic	1	2	3

In the case here considered, the database, obtained by the previously described elaboration, has been referred to the 2256 census divisions of the Municipality of Florence.
Geographic Information Systems (GIS) allowed linking this database to vectorial maps of the territory, as shown in figure 1.
This method offers the following advantages:
- strong support in drawing up planning on noise pollution control;
- easy management of planning and of its upgrade without attendance of specialised staff;
- possibility of interaction between Urban Development Planning and noise pollution control;
- possibility of establishing priorities in projects to reduce noise pollution;
- management of open field measurements and their handling by GIS.

This methodology can be very powerful and useful, but it is important to remember that, like any development tool, it requires anyway a critical analysis of the results.
In fact, the automatic treatment of data can involve a classification that can be contradictory and difficult to be applied, such as an excessive fragmentation of the territory into different acoustical areas.
Moreover, a particular criterion has been applied to areas closed to main roads and railways,

according to national and locale guidelines. From these considerations and the analysis of Urban Development Plan, we obtain the final acoustical classification represented (figure 1).

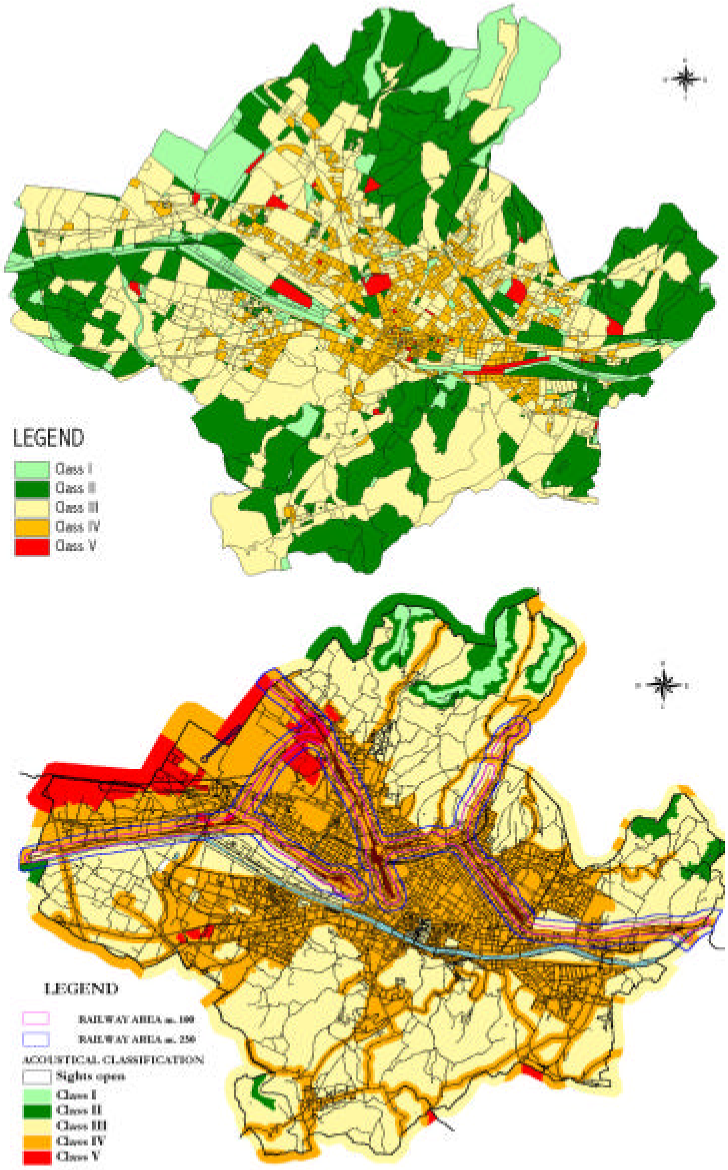

Figure 1: Florence municipality: the acoustical classification of the 2256 census areas (above) and the final acoustical classification (below).

THE ACOUSTICAL CLIMATE OF FLORENCE

The acoustical climate of Florence has been analysed referring to the data measured by the Regional Agency of Tuscany during the period from 1990 to 2001.

Where the data measured by the Regional Agency were not sufficient to characterise the acoustic environment of the territory, specific short measurements have been carried out.

This way, a great number of acoustic data has been implemented in the Geographic Information System used for the definition of the acoustic plan.

From the comparison of these data with the limiting values defined by the acoustic classification plan, a series of criticalities has been pointed out.

In figure 2 the position of the measurement points is showed. The size of each point is referred to the difference between the measured value (as equivalent sound pressure level in the daytime) and the limiting value.

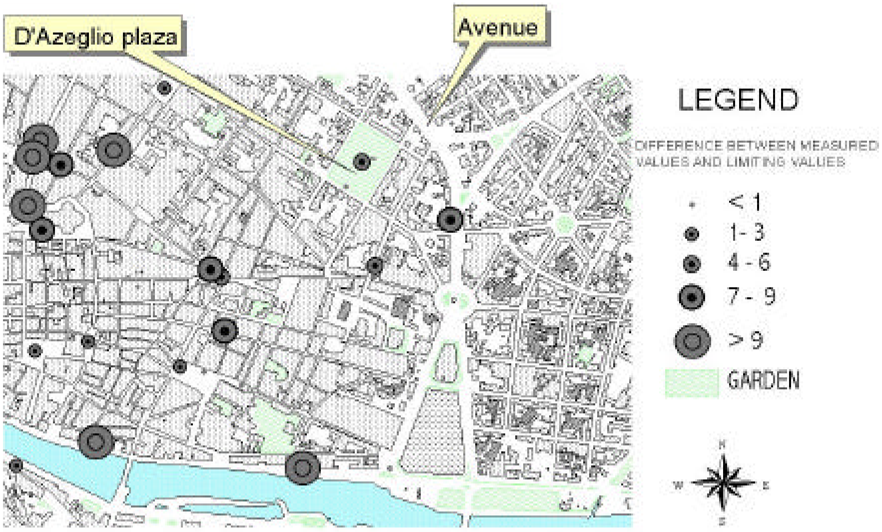

Figure 2: Difference between measured sound pressure level in the daytime and acoustical class limits.

ACOUSTIC IMPROVEMENT OF TOWNS: CASE STUDIES

The Italian Law has introduced the plan for the acoustic improvement of the territory which is obligatory when the sound levels measured exceed the limiting values defined for each area by the acoustic classification plan (figure 1, below).
In the case of the Municipality of Florence, this plan has not yet been defined, but, from the comparison between the limiting values defined and the measured values, it is clear that there are many cases that need a strong acoustic improvement.
In particular, and only as examples, the boulevards which delimitate the historical centre (realised in the place of the medieval walls) are characterised by daytime equivalent SPL of about 75 dBA and by a limiting value of 65 dBA (class IV). Moreover, many squares are characterised by Daytime SPL of 60 – 65 dBA.
In the following two case studies are presented, with reference to the survey of typical situations of acoustical criticality, which contemplates:

- main urban roads, with intense traffic;
- residential roads, with local traffic;
- squares;
- gardens.

In particular, the first case study concerns a boulevard with a school on one side and a cycling path.
The second case study concerns a great square very important for the people of the district, with a football course and children plays inside of it.
These case studies can be seen as possible solutions for similar situation in the town of Florence such as in other towns.
In both case a new series of measurements have been carried out to better characterise the acoustic environment.
Some simulations of the sound propagation have been carried out by mean of a software utilizing algorithms of the German standard RLS 90 (equal to that defined by DIN 18005). The software has been calibrated with reference to the sound pressure levels measured in the actual state.

FIRST CASE STUDY: THE PLAZA

D'Azeglio plaza is a garden very lived by the population in Florence: the strategic position next to the centre of the city, in a residential district, makes this space a sort of green lung in the middle of the built one. Besides, the proximity to the complex of the University and to other schools, it recalls a very varied use: from the students, to the children and elderly.

This makes very important an intervention of mitigation of the urban traffic noise.
We have decided then:

- to realize a sound barrier on the side of the plaza in proximity of the noisiest side;
- to maintain the main access to the plaza from this same side;
- to realize a bus platform, that can also acquit the function of sound barrier.

A platform with modular structure, constituted from uppercuts and from noise reduction panels that can be assembled with the purpose to create a real sound barrier. Moreover, It could then be fitted with anterior, back and side glass showcase for information panels.
On both sides of the bus platform and behind of it, two vegetative barriers with plants of jasmine will be positioned.
Considering the curtain of buildings surrounding the plaza, it seemed interesting to maintain the contrast among the very shut of the surrounding and the space open.
D'Azeglio plaza, according to the plan of acoustic classification, is found in class IV, the values limit to be respected being 65 dBA in daytime and 55 dBA in night time.
Equivalent Weighted Sound Pressure level in the actual state variable between about 55 and 65 dBA, being greater in the proximity of the main road, where the bus platform – barrier has to be positioned.
We are set as objective to achieve an acoustic climate with sound levels of 10 dBA lower than those specified by the acoustic regulations; so we must have 55 dBA in daytime and 45 dBA in night time.

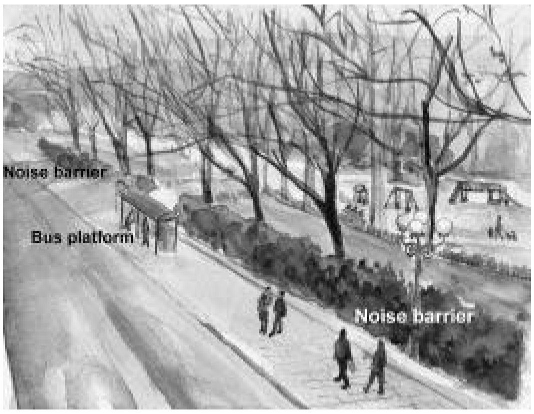

Figure 3: actual state (left) and project (right) for the plaza

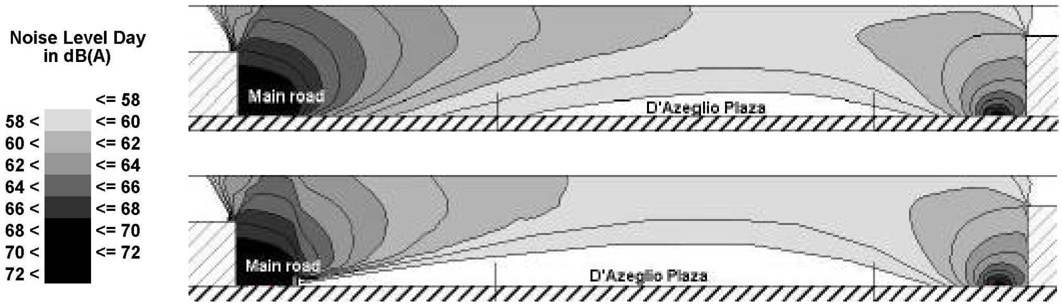

Figure 4: Acoustic simulations in the actual state (left) and in the project (right) for the square.

Through the analysis of the results obtained by the simulations, carried out by means of the program mentioned above, these values are achieved installing a sound barrier 2 meters height.
Figure 3 shows the comparison between the actual state (photo) and the project (draw), while figure 4 shows the results of the final simulations.

SECOND CASE STUDY: THE AVENUE

Spartaco Lavagnini Avenue is a road with intense traffic that belongs to the bypass in Florence.
The different avenues constituting the bypass of the town are very similar and so the individualized solution could be proposed in other similar contexts.

The avenue is adjacent to an elementary school that is classified by the Italian Law as sensitive receptor. Therefore, it is necessary to mitigate the sound levels within the limits established by the acoustic regulations.
The problem of the acoustic and atmospheric pollution has sensitised the local administrations as it regards the promotion of vehicles alternative to the private car, stimulating therefore the use of the bicycle and the consequent realization cycling paths.
At present, the cycling paths are adjacent to the sidewalks and separated by the avenue by a car lot. We have decided to create a better hierarchy for the runs, such to allow a suitable accessibility to all the spaces, following these priorities: pedestrian – bicyclist - car driver.
We have obtained this result by removing the car parking from this side of the avenue.
The hierarchy of the runs is insured also from the differentiation of the materials: asphalt for the avenue, coloured concrete for the cycling path and grey stone for the sidewalks.
Moreover, we have decided to insert a barrier made of metacrilate with jasmine plants.
In correspondence of the school, we have separated the pedestrian runs from the cycling paths by diverting the second and creating an ampler pedestrian space. In this line, the cycling path will be protected from a barrier with a greater height.
The avenue, according to the plan of acoustic classification, it is found in class IV, the values limit to be respected being 65 dBA in daytime and 55 dBA in nighttime.
Equivalent Weighted Sound Pressure level in the actual state is about 75 dBA.
Keeping in count the complexity of the problem, we are set as objective to achieve an acoustic climate with sound levels lower than 70 dBA in daytime.
Through the analysis of the results of the simulations (figure 6), the above objective is obtained by installing a sound barrier 2 meters height.

Figure 5: actual state (left) and project (right) for the avenue.

CONCLUSIONS

Sound pressure levels measured in the urban area of Florence are very frequently greater of many decibels than the limiting values defined by the acoustic classification plan.
A plan for the improvement of the acoustic climate of the town is not yet been defined.
The paper reports some general considerations about the acoustic climate of Florence and shows a comparison between measured and limiting values of SPL in the urban area.
Two case studies, referring to typical configuration of urban spaces, are presented and proposals of sound mitigation analysed by means of simulation software.

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