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The H.U.S.H. project - database of noise reduction measures for city noise action planning

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PACS: 43.50.Gf Noise control at source: redesign, application of absorptive materials and reactive elements, mufflers, noise silencers, noise barriers, and attenuators, etc. (see also 43.55.Dt); 43.50.Sr Community noise, noise zoning, by-laws, and legislation

ABSTRACT

The H.U.S.H. (Harmonization of Urban noise reduction Strategies for Homogeneous action plans) project moves from the evidence that harmonization of noise action planning methods is needed not only in Italy but also in all the European countries where a former Legislation about noise planning was present at the moment of END Directive adoption. The general objective is harmonizing the national noise management standards with European Directive 49/2002 to obtain homogeneous noise Action Plans, contributing to the more general need of transposing, implementing and enforcing a common or harmonized environmental legislation among EU countries.
Specific objectives of the project are:
1. to point out unsolved conflicts among current standards at Regional, National and European level, and to define common methods for designing strategic and specific solutions;
2. to define a new development system (procedures and database) for action planning by testing it in two pilot cases (both of them in the city of Florence);
3. to design guidelines in order to build a system for action plan applications, to support Regional, National and European Law reviews.
In this paper the results coming out from action 5 of H.U.S.H. project are described.
This specific action focuses on collecting a database of solution cases for the reduction of noise in urban areas. Such collection will provide a significant contribution to further development of the Action Planning work platform. Collected data have been analyzed and compared with the state of art.

1. INTRODUCTION

The authors of this paper are respectively the Project Manager of Vie En.Ro.Se. Ingegneria, a company of acoustician experts playing the role of action 5 developer, and the Technical Project Manager of the H.U.S.H. project.
The main objective of the mentioned action in the frame of H.U.S.H. project, is to provide a collection of information, catalogued on typological basis, usable as summary of design methodologies adopted at the end of project. to be shared with other partners.
To achieve this aim, the proposed methodology starts from an initial phase regarding published studies and researches, followed by another of investigation carried out through direct contacts with the cities where case studies could be found.
The activity of direct data collection has been defined in collaboration with Dept. DMTI of University of Florence (H.U.S.H. Partner responsible of data bases collection for Noise Mapping and Action Plans). Cities have been selected first, then a checklist administered directly by the chosen cities has been selected as the most significant for data collection.
Specifically, the checklist sections concerning different solutions and scenarios for acoustic improvement, adopted by Italian and European cities in urban areas, are described in this work.
Several one-to-one meetings have been organized for collecting data about experiences realized in Italian cities, aiming to complete the check list. At the same time the check list has been proposed to EU cities, members of Eurocities Working Group Noise, for collecting data about experiences realized there.

2. DATA COLLECTION

The methods listed below have been employed.

- For what concerns scientific materials and articles, some on-line libraries have been consulted as well as the database of Documenta Acustica, the literary information and distribution product of European Acoustics Association (where congresses proceedings, books, technical reports etc. are collected).
- For what concerns the already carried out design solutions, a general research has been conducted in competent offices of Cities, Regions and National Ministry of Environment, as well as in main companies managing National and local transport services.
- A general checklist is produced, joining the parts produced by Vie En.Ro.Se. and DMTI, comparing what

produced by each partner, and structuring a single document during joint meetings. The checklist has been produced in Italian and English, for the distribution to non-Italian cities and for the next phase of dissemination of project results;

- The checklist was then tested; feedback and comments have been requested and collected; after appropriate revisions and corrections, it has been administered through meetings with representatives of the identidied cities.
- All the design actions and documents, previously produced by Vie En.Ro.Se. (responsible partner for bringing in completion this action) have been of course taken in account.
- Possible point solutions (on sources, on propagation paths, direct to buildings), and "strategic" actions for the acoustic improvement of entire urban areas have been collected and catalogued.

The previous listed activities bring to the definition of a summary table, detailing:

- different typologies of noise reduction interventions currently available;
- their most appropriate application field, relatively to effectiveness and cost/benefit ratio;
- predictable unit cost and average benefit, under established conditions of use.

2.1 Definition and classification of sources

During the preparatory phase, a research regarding the state of the art of published studies on what has been done on acoustic improvement in urban areas, has been carried out.
The collection of bibliographic materials has been focused on researches and theoretical studies concerning the various possible solutions for noise mitigation in urban areas (typologies, effectiveness, etc.) and articles on case studies (projects, their effectiveness, etc.). In particular reports and results of EU research projects like HARMONOISE, IMAGINE, SILENCE, QCITY have been considered.
In addition, data collected by the Regional Agencies for Environmental Protection were consulted. This review covers researches and collection of European documentation currently existing in particular with regard to issues of population exposure to noise generated by traffic.

2.2 Definition of sample cities for data collection

For the selection of sample cities, a preliminary screening among the most "virtuous" Italian and European cities in terms of application of European regulations and local noise pollution rules was carried out, through a specially commissioned research.
Starting from collected information, a first group of Italian and European cities has been directly contacted, requiring a willingness to participate in a one-to-one meeting for data collection arranged by their offices.
With regard to European cities, contacts have been taken during the Spring Meeting of Eurocities WG Noise, held in Helsinki on 16 and 17 April 2010 where a considerable time in agenda has been devoted to the presentation of H.U.S.H. project.
The checklist had been previously sent to the cities members of the Working Group; cities have had time to make any comments, to be discussed during the Spring Meeting in Helsinki, and data were finally collected in the following weeks. Extending the H.U.S.H. project provisions, where information are to be gathered only in two Italian and one European cities, a broader number of cities has been involved, considering the interest generated by the project.

The following table shows, for each type of activity, the cities where data have been collected.

Table 1. List of sample cities

City	Data collection	
	checklist (meetings with city offices)	literature
Florence (Italy)	x	
Turin (Italy)	x	
Milan (Italy)	x	
Grand Lyon (France)	x	
Oslo (Norway)	x	
Rotterdam (Netherlands)	x	
Dublin (Ireland)	x	
Rijeka (Croatia)	x	
Helsinki (Finland)	x	
Massa Cozzile-PT (Italy)	x	
Figline Valdarno - FI (Italy)	x	
Borgo San Lorenzo - FI (Italy)	x	
Pisa (Italy)		x
Darfo Boario - BS (Italy)		x
Rastignano - Bologna (Italy)		x
Caselle Torinese - Turin (Italy)		x
Chiasso (Switzerland)		x
San Benedetto del Tronto - AP (Italy)		x
Ancona (Italy)		x
Imola - Modena (Italy)		x
Villa Cella - RE (Italy)		x
Curitiba (Brazil)		x
Maranello - Modena (Italy)		x
Catania (Italy)		x
Naples (Italy)		x
Cornaredo - MI (Italy)		x

2.3 Checklist definition

The Checklist on noise management and reduction techniques adopted in investigated cities has been structured to acquire the following information:

- Type of intervention (on source, on propagation paths, on buildings, "strategic" actions, etc.).
- Application field (typical boundary conditions assumed to determine the interventions effectiveness).
- Estimated or measured effectiveness during design or testing phase, in terms of achieved noise reduction.
- Unit costs of described interventions.

In the following figure the checklist section regarding noise mitigation and reduction sistems adopted in the cities is shown.

INTERVENTIONS				
TYPOLOGY		APPLICATION FIELD	NOISE REDUCTION	COSTS
source	Yes/No			
low noise pavings				
chicane				
roundabout				
tunnel				
speed camera				
speed hump				
traffic light for speed riduction				
propagation pattern	Yes/No			
noise barriers				
tunnel				
On buildings	Yes/No			
Facade insulation				
Strategic	Yes/No			
changes of traffic planning				
other transport systems				
reduction of residential				
other				
If possible, attach the report (in .pdf or .doc format) containing the design of interventions and ante/post operam assessment				
PLANNING OF INTERVENTIONS				
economic resources and time				

Figure 1. Checklist section

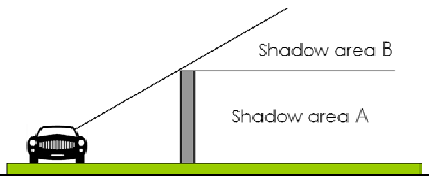
2.4 Data collection analysis

In order to make available, accessible and truly comparable data collection and in order to allow their use for designing and planning of noise reduction activities, information collected were cataloged in a series of descriptive sheets. Each sheet represents a macro type of action (noise barriers, low noise pavings etc.) specifying different possible applicative solutions for it. The scheme of the sheet provides a fixed structure, characterized by the following fields:

- specifications;
- effectiveness in terms of noise mitigation;
- typical use related to different urban environment and contexts to be reclaimed;
- advantages and disadvantages connected to the type of intervention.

The collection of sheets has the general purpose of supporting different levels of acknowledgement, referred to all the involved stakeholders. From the divulgation of basic noise control and reduction methods to technical support planners, designers and policy makers. Some examples of the more descripitive general purpose sheets are shown below.

Noise Barriers



GENERAL DESCRIPTION

The purpose of noise barriers is to reduce the amount of sound pressure reaching the recievers.

In practice barrier is interposed between the source and the receiver so that the sound waves reach receivers only by diffraction.

A generic barrier can be considered a good technical solution if it guarantees an attenuation of 10-15 dB compared to the level that would be measured without them. In terms of construction noise barriers can be classified in two main categories: artificial (constituted by panels having different insulation or absorption acoustics properties), or natural (earthwork or similar).

From the acoustical point of view, noise barriers can be divided according to their quality: sound-insulating, when the energy of the incident wave is mainly reflected by the barrier, sound-absorbing, when the energy of the incident wave is reflected and absorbed by the barrier.

The effectiveness of the barrier depends on:

- Location: barriers should be placed as close as possible to the sound source;
- Height: visibility of the source by the receivers should not be allowed;
- Length: to minimize lateral diffraction effects producing a reduction of mitigation;
- Thickness: to reduces the amount of diffracted energy that reaches the receiver;
- Sound insulation: it shall be sufficient to make negligible the contribution of transmitted than reflected or diffracted energy;
- Sound-Absorbing: determines attenuation of sound propagation.
- The decision to insert a noise barriers must however consider their impact on visual and landscape.

Source: Action 5 H.U.S.H. Project Report - 2010

Figure 2. Noise barriers sheet

Metal Panel

DESCRIPTION

This type of barrier is composed of modular elements, characterized by a "sandwich" structure consisting of two layers of steel or aluminum coated with a compact varnish, within which a layer of soundproofing material is inserted. The plates present, on the side exposed to the noise source, different diameter holes (normally a few mm in diameter) that help the spread of noise within the panel, where the sound-absorbing material (usually made of wool, mineral wool or glass wool) is inserted.

The shell of metal panels used as components in acoustic noise barriers for transport infrastructure can be made of aluminum alloy, steel or other metal, suitably protected against corrosion (phenomenon that can be caused also by mistakes in designing or not adequate surface treatments). The alloy should not be permanently in contact with material of different electrical potential to prevent galvanic corrosion effect. This type of panel has good characteristics with regard to the small footprint, lightweight, sound-absorbing properties and cost. Because of their visual impact, not always their placement in special environmental landscape is allowed.

ADVANTAGES

- Easy assembling;
- Possibility of different colors;
- Lightness;
- Excellent soundproofing;
- Costs.

DISADVANTAGES

- Issues regarding corrosion due to weathering;
- Maintenance more expensive than other typologies of panels;
- In some contexts this kind of metal panels presents problems regarding environmental acceptability.

Source: Action 5 H.U.S.H. Project Report – 2010

Figure 3. Noise barriers sheet (Metal Panels)

Low noise pavings

Sound-absorbing asphalts (also known with the acronym of CDF, "conglomerates draining acoustic") are mixtures in which the aggregates have a particular grading curve, and a voids percentage much higher than that of conventional asphalt.
The high percentage of empty spaces allows easy drainage of rainwater from the road, so that these asphalts are defined "draining asphalts".
The dissipation of noise emitted from the tire rolls on the road surface is due to the empty spaces on the asphalt, exploiting the ability of sound absorption characteristic of porous materials.
At a general level, it is recognized that asphalt thickness of about 4 cm, voids percentage greater than 18% and up to 25%, size of aggregates 0 / 10 or 0 / 12, are able to halve total noise energy emitted by a source placed above them (reduction of 3 dBA) compared with a traditional dense asphalt.
Main framework for implementing these asphalt is out of town (when normal vehicles speed transit exceeds 50 km/h), but significant reductions have been achieved even in urban contexts.

Source: Action 5 H.U.S.H. Project Report - 2010
Figure 4. Low noise pavings

Double layer asphalt CDF

The rapid time-decay of draining power and acoustic properties, caused by obstruction of porous asphalt layed in a single layer (in urban areas a year after the laying, average abatement decreases by an order of 3 to 3.5 dBA to 1.0-1,5 dBA) led to develop a new generation of double-layer drainage asphalt.
These road surfaces consist of an upper layer of fine grain size of 4-8 mm corresponding to a thickness of 1.5-2 cm, that works to filter out impurities, and a lower layer of larger particle size of 11-16 mm, corresponding to a thickness of 3.5-4 cm for the drainage of meteoric water, using the self-cleaning ability due to the passage of vehicles (from experiences in Europe, it has been shown that their acoustic properties remain unchanged for 4-5 years).
In addition to the properties of reducing noise depending on their porosity, the asphalt CDF double layer, , reduce the phenomena of vibration of the tire also because of its finer texture of the top layer. It's possible to get reductions in order of 3.5 dBA.
ADVANTAGES

- Self-cleaning properties: the passage of vehicles, particularly of the heavy ones, sends the air pressure into the voids of the lower layer; the same air, escaping to the surface, removes dust and other residuals remaining (as a filter) inside the micro-draining cavity layer;
- High sound absorption coefficient (also equal to 0.9 with a maximum at frequencies between 500Hz and 700Hz) with long-lasting performance;
- Particularly suitable in urban environments.

DISADVANTAGES

- High cost for laying the pavings

Source: Action 5 H.U.S.H. Project Report - 2010
Figure 5. Double layer asphalt CDF

3. SUMMARY TABLE OF NOISE REDUCTION INTERVENTIONS

As final result of the action a summary table where different types of interventions are described has been structured; the characteristics of interventions have been related to their typical application field (to optimize cost-effectiveness ratio), and the corresponding unit costs have been calculated, together with the estimated average benefit.
The structure of the final summary table, filled with some sample fields, regarding sheets above mentioned, is shown below.

Table 2. Summary table section

Intervention	Typical application field	Effectiveness (Reduction [dB (A)]	Cost
Noise barriers with metal panels	Typically used in case of medium height receivers in proximity of infrastructure	14 dB for receivers in the A barrier shadow area; 7 dB for receivers in the B barrier shadow area; 0 dB for receivers out of the barrier shadow area	€ 200/m^2 excluding costs of foundations
Double layer asphalt CDF	Good in not particularly critical urban area situations or as integration of other interventions	3.5 dB for all receivers	€ 25/m^2
...			

In synthesis, one of the main objectives of this H.U.S.H. project action was to check if there were, at Italian or European level, official informations that could be used as structured and updated support for designers, assisting them in the definition and planning noise reduction interventions. In lack of this, it was up to the project action developer to collect data and organize a database of information to be published and made available to the public.
Researches showed that the only available official table in Italian Legislation is the one attached to the Ministerial Decree 29/11/2000, containing different typologies of noise reduction measures and their out-of-date standard costs (year 2000). Nothing similar have been found in European Legislation. Collected data have been organized into a table based on what is available yet. Typologies and costs of interventions have been updated only when supported by a statistically significant number of cases, updating process regarding not only the cost of materials but also of their installation. New types of interventions defined as "strategic"

like the placement of road narrowing systems and roundabouts have been added.
In authors' opinion this could be a good system for the collection and the dissemination of knowhow relative to different aspects of noise reduction interventions, though at this stage on the base of available information, not all types of actions could be summarizes.
New and different noise reduction methods in urban area, identified by authors as strategic, must necessarily be considered, and catalogued in the future, as soon as more data will be available.
The sharing of informations by means of updated and periodically verified tables, published on public websites and where possible approved by deputed official bodies, appears an useful tool not only for tecnicians, but also as decision support for those who have political responsibilities in action planning policies.

4. CONCLUSIONS

The results of this action, as a part of H.U.S.H. project 1st phase, show a substantial criticality regarding the available data. Although theoretical studies and designing data are available in literature, informations regarding costs for the implementation of intervention and results regarding testing are difficult to find, with special regard to the acoustic effectiveness verification of specific interventions.
Really few information are available about the maintenance programs and related costs, as well as about the data on effectiveness and costs in respect of strategic actions.
Data collection and results of this action are strictly correlated with those of action no. 2 produced by Dept. DMTI of University of Florence, concerning the definition of the structure of the database used for the construction of noise mapping and action plans.

LIST OF HUSH PROJECT REFERENCES

1 HARMONOISE Project - Harmonised, Accurate and Reliable Methods for the EU Directive on the Assessment and Management of Environmental Noise
2 IMAGINE Project - Improved Methods for the Assessment of the Generic Impact of Noise in the Environment, 6th Framework Programme of the European Community
3 SILENCE Project – Progetto di ricerca finanziato dal 6th Framework Programme of the European Community
4 CALM II Project - Coordination of European Research for Advanced Transport Noise Mitigation, 6th Framework Programme of the European Community
5 QCITY Project - Research, technological development and implementation of innovative concepts for quieter cities, 6th Framework Programme of the European Community
4 ACTA ACUSTICA UNITED WITH ACUSTICA, The Journal of the European Acoustics Association (EAA) and the International Journal on Acoustics (2007-2008-2009)
5 RIVISTA ITALIANA DI ACUSTICA, The Journal of Italian Acoustics Association (2007-2008-2009)
6 PROCEEDINGS OF CONGRESSES ON ACOUSTICS (2007-2008-2009), LISTED BELOW:

- AIA (Italian Acoustics Association) National Congress
- EAA Forum Acusticum
- ICA, International Congress of Acoustics
- EAA Euronoise
- I-INCE Inter-Noise
- ICSV - International Congress on Sound and Vibration

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