



48º CONGRESO ESPAÑOL DE ACÚSTICA
ENCUENTRO IBÉRICO DE ACÚSTICA
EUROPEAN SYMPOSIUM ON UNDERWATER ACOUSTICS
APPLICATIONS
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ACOUSTICS

HOLISTIC APPROACHES IN URBAN PLANNING AND IN THE ACOUSTIC DESIGN OF BUILDINGS

PACS: 43.50.Rq, 43.55.Br

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Keywords: acoustic design, sustainability, holistic

ABSTRACT

Soundscapes play a decisive and discriminating role in the urban scenarios, made of noisy and (hopefully) quiet areas. The design of built environment must consider living and working spaces where man-made elements, machineries and infrastructures are often real landmarks as well as their sounds and noises are soundmarks.

In the holistic design integrated approach, based on the idea of safeguarding people's health, comfort and serenity, acoustics is one of the founding elements of the man-habitat-environment system.

Some examples of solutions for the design of acoustic quality in urban areas and buildings are shown, giving evidence to aspects like multisensory approach for global comfort, choice of sustainable acoustic materials as a part of the circular economy and users opinion, in terms of noise awareness and participatory design.

INTRODUCTION

Environmental sustainability is the ability to keep ecological processes within an ecosystem and its biodiversity in the future.

The three conditions of environmental, economic and social sustainability contribute together to the definition of well-being and progress.

Sustainable growth is the greatest challenge of the 21st Century. In this frame, circular economy and holistic approach in planning urban areas and designing public and private buildings, play a decisive role.

Circular economy is an economic system that can regenerate its own. In a circular economy, material flows are of two types: biological ones, capable of being reintegrated into the biosphere, and technical ones, destined to be re-valORIZED without entering the biosphere.

The holistic approach consider a plan or a design relating to complete systems rather than with its parts. Analysis of systems and design of solutions for problems consider the system as a whole: holistic medicine attempts to treat both the mind and the body, holistic ecology views humans and the environment as a single system.



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Holistic designer of urban areas and buildings, moving from the concept of holism, try to apply to their designed works the idea that the whole is more than merely the sum of its parts, in theory, and above all, in practice. In the frame of circular economy, holistic design is also based on the attenuation of impacts: this corresponds to the use of materials characterized by reactive intelligence, as a coherent composition of natural and artificial materials which well adapts to the characterization of works in delicate contexts. In the example shown in this paper this specific matter of effectiveness has been applied by the designers.

SUSTAINABILITY AND QUALITY OF LIFE IN URBAN AREAS

For many years urbanization has been associated to keywords like industrialization, construction, infrastructures, transportation networks, mobility, energy. In the present time a new set of keywords, including participation, communication, urban performance, quality of life, smartness, sustainability, has been defined.

A smart and sustainable urbanization is needed: administrations of cities and large metropolitan areas are directly responsible for local policies, which directly affect the health and well-being of citizens and, at the same time, are called to greater responsibility, sometimes not having enough available resources for reaching the objectives.

In many cities there are several and perhaps too many plans concerning traffic, housing, land use, and services, with no strategic integration or harmonization among them.

On the contrary, strategic planning should start from basic concepts such as compactness, completeness, conservation, comfort, coordination and collaboration.

As far as existing land management policies are concerned, they should develop strategies for the integration of energy-conservation, resource-optimization and environmental pollution mitigation strategies.

In Europe, land of connected cities, the growing number of urbanized areas, and of population living in these areas, requires a growth in urban performance.

Man-made elements and their sounds play a decisive and discriminating role in the urban scenarios, made of buildings and infrastructures, characterized by noisy areas.

In the outdoors of cities the need of a new definition of quiet areas in terms of comfortable places emerges, since urban landscapes (and soundscapes) are perceived as “world around us” and not “world in front of us”, meaning that places are inhabited by the observers and, in these places, sounds and noise are basic elements of quality of life.

HOLISTIC DESIGN AND THE ACOUSTICIANS

Which role could (should) play the acousticians, as acoustic planners and acoustic designers, in the above described scenario?

Usually, acousticians are considered like mere technical interfaces for real, presumed, potential polluters and for real, presumed, potential polluted people; they do this for control authorities and policy makers as well. Sometimes they assume the status of forensic assistant, technical auxiliary of the Judge in legal disputes regarding noise. Within the END Directive disposals, acousticians working in agencies or as consultants assist the Local Governments in developing noise maps and, above all, action plans.

But the most important contribution given by acousticians to sustainable growth and quality of life improvement is when they act as acoustic designers of actions and solutions for noise mitigation and reduction of annoyance in outdoor areas and buildings, for comfortable soundscapes in urban spaces, for listening good sounds. Despite the fact that in projects regarding urban areas and buildings acoustics is often considered a secondary component in terms of impact on the overall budget and on the specific budget for the design, the level of acoustician competences and of acousticians' involvement can be crucial for the success of a sustainable policy or for building comfortable places.

In urban areas, where noise control and soundscapes design are required, the holistic approach shows particular effectiveness.

Acousticians can go holistic, considering smartness and serendipity. In the Smart Cities approach (smart mobility, housing, urban planning,...) various connections with noise control and noise reduction can be found. There are many links between strategic actions and solutions for environmental noise and other relevant urban planning actions, such as air quality control, mobility, etc. As an example, in the case study represented by the pilot area of Life MONZA Project, reported in the following chapter, a new definition of Low Emission Zone, considering air quality and noise control is provided and smart holistic solutions will be implemented.

The holistic design can lead to important serendipic effects in terms of secondary benefits given as added values to the acoustic benefit at the same cost, and vice versa. It allows to achieve the primary objective of the design together with one or more free secondary pleasant added benefit. Finally the holistic approach considers participation and awareness: Participatory Design schemes are implemented since the first phases of planning and design, collecting Stakeholders opinions on strategic issues, analysing end user questionnaires to collect the perceived level of acoustic comfort and acoustic quality of investigated areas, aiming to carry out, via simple analysis, useful results for designing phase. Noise Awareness Campaigns should be set as integrating part of the design.

Informative materials on noise and its effects should be produced and distributed with specific attention to situations where noise is actually a local public health problem. Ideas for original solutions can be derived from feedbacks to awareness campaigns

In the following chapters examples of holistic approach to the acoustic design of places are described.

EXAMPLE OF HOLISTIC URBAN PLANNING – THE NOISE LOW EMISSION ZONES

Low Emission Zones (LEZ) have been implemented in more than 100 cities in Europe and they are the most common measures adopted in EU, considering traffic planning. EU Directive 2008/50/EC on ambient air quality and cleaner air for Europe considers the establishment of LEZ a measure to be adopted in air quality action plans. The introduction of Low Emission Zones, urban areas subject to road traffic restrictions in order to ensure compliance with the air pollutants limit values, set by the a common and well-established action in the administrative government of the cities. The impacts on air quality improvement are widely analyzed, whereas the effects and benefits concerning the noise have not been addressed in a comprehensive manner. At the same time, there is a lack of a comprehensive and integrated administration process about LEZs. The definition, the criteria for analysis and the management methods of a Noise Low Emission Zone are not clearly expressed and shared yet.

The project LIFE MONZA (acronym of Methodologies fOr Noise low emission Zones introduction And management - LIFE15 ENV/ IT/000586) addresses these issues.

The first objective of the project is to introduce an easy-replicable method, and related guidelines, for the identification and the management of the Noise Low Emission Zone, intended as urban areas subjected to traffic restrictions, whose impacts and benefits regarding noise issues will be analyzed and tested in the pilot area of the city of Monza, located in North Italy.

The second objective regards specific top-down measures, adopted by the municipality and able to turn up the area in a permanent Noise LEZ, concerning traffic management, road paving substitution and introduction of two pedestrian crossings.

The third objective is to reduce the average noise levels in the pilot area of Libertà district, with positive complementary effects also on the air quality and benefits on wellbeing conditions of inhabitants.

The fourth objective is to involve people in an active management system of a more sustainable lifestyle choices (bottom-up measures), related to the reduction of noise and the improvement of air quality and wellbeing conditions, in their living and working environment. In order to encourage the local community involvement and to strengthen the dialogue between citizens

and public bodies, many activities will be carried out, as meetings in primary and high schools, in order to raise awareness about noise effects, and also ideas contests for Noise LEZ picture and

logo and questionnaires on quality of life and noise perception. A mobile app to manage voluntary and sustainable actions and to measure benefits and concrete changes in people lifestyle will be developed.

In order to contribute to the implementation of the European directives, avoiding duplications and overlaps, detection of the synergies existing between the issues related to noise pollution and air quality will be tested during the project.

The four objectives have been translated in five main project actions, described in figure 1.

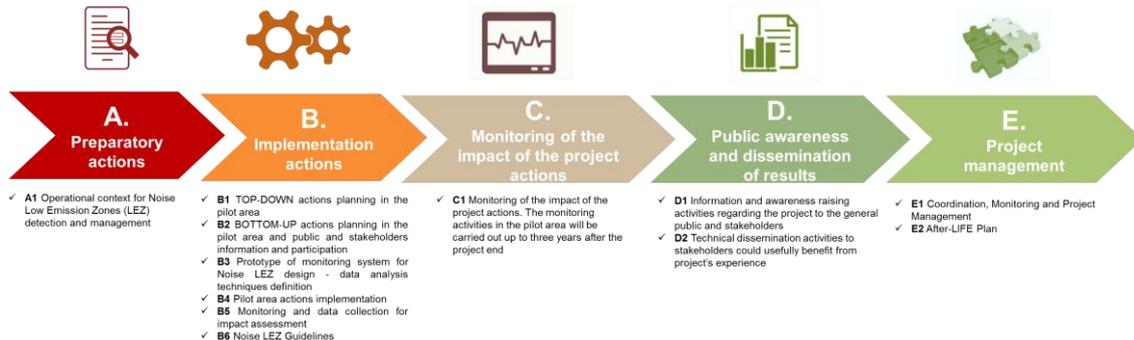


Figure 1 – The actions' scheme of LIFE MONZA project

Focusing on the Air Quality monitoring within the pilot area, according to requirements provided by Directive 2008/50/EC, low cost and easy diffusive sampling techniques are used for a large scale air pollution surveys with a high spatial resolution. In order to compare the spatial variability of air pollution before and after the noise LEZ implementation, NO₂ and benzene land use regression models in a defined urban area of Monza, including the noise LEZ, are developed. The objectives of monitoring will be to assess whether the implementation of the noise low emission zone contributes, as an ancillary and serendipic effect, to reduce air pollution levels in the pilot area.

Quality of life is monitored as well, via a two-step survey performed before and after the institution of the noise LEZ zone (about 2000 citizens and stakeholders are involved). The WHO QOL-Bref questionnaire, is used as it is the only tool that has a specific environmental section, validated in Italian language. It comprises 26 items, which measure the following broad domains: physical health, psychological health, social relationships, and environment.

Finally, regarding the noise monitoring phases planned in pilot area, the activities are carried out referring to the standard methods, using sound level meters of class I precision, and also by developing and using a smart low-cost monitoring system.

A prototype system for smart monitoring has been designed and implemented, in order to be used as a continuous monitoring unit. In particular, the state of art about smart noise monitoring systems has been defined by the Italian National Environmental Agency (ISPRA), and a smart monitoring system design and data analysis procedures have been implemented by the Department of Industrial Engineering of the University of Florence (DIEF), both partners of LIFE MONZA project. Smart low-cost noise monitoring systems, allowing an extensive and long-term noise monitoring, in medium sized territorial scale as urban area, seem to be able to ensure an appreciated quality output measurement data. 10 monitoring stations are expected to be installed in the pilot area of Libertà district.

After the end of LIFE MONZA project, the prototype will be given for free to Municipality of Monza that will take care of using it for monitoring activities in the three years after the project end.

The methodology will contribute to the implementation of the EU Directive 2002/49/EC, related to the assessment and management of environmental noise (Environmental Noise Directive - END), which introduces noise action plans, designed to manage noise issues and effect, including noise reduction if necessary. The area interested by Noise LEZ in the city of Monza is represented in figure 2 and in figure 3 the monitoring points are indicated.

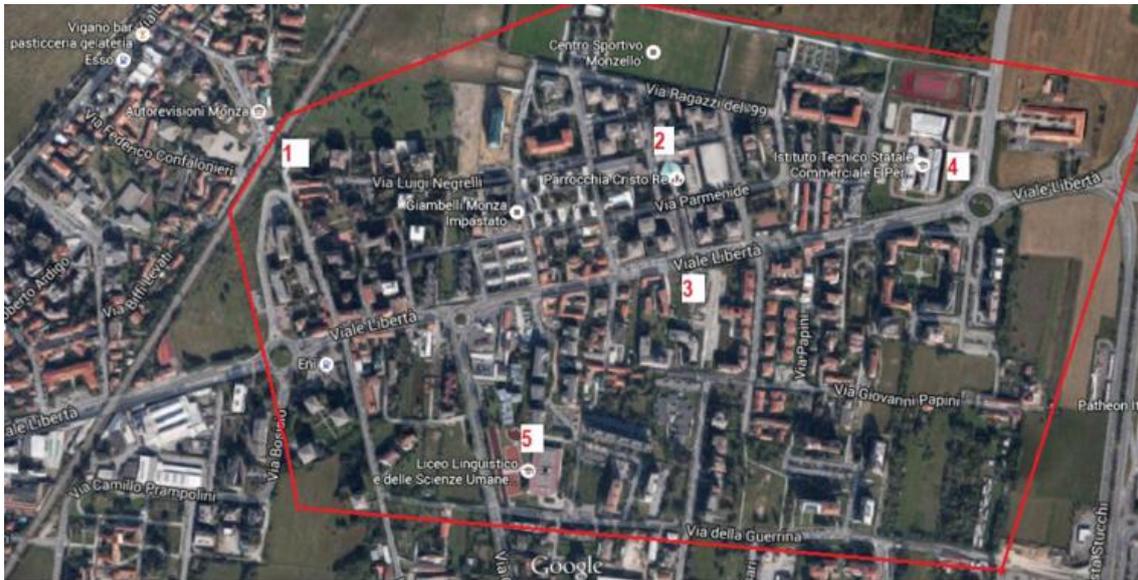


Figure 2 – The pilot area of LIFE MONZA project

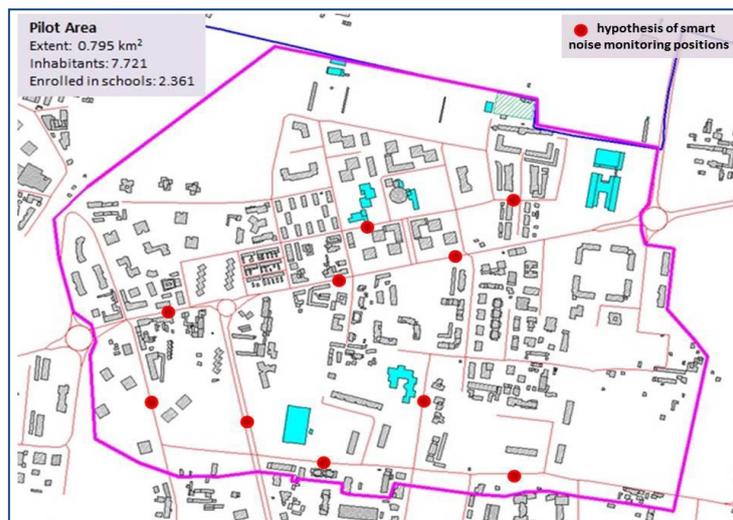


Figure 3 – Monitoring points

RECYCLED AND SUSTAINABLE MATERIALS IN BUILDINGS

The main sustainable acoustic materials examined are recycled rubber from exhausted tires, polyester fiber, recycled textile fibers, polylactic acid fibers (corn), vegetable fibers (cotton, hemp, coconut, cellulose, etc.), animal origin fibers (sheep wool, goose feathers, etc.), evergreen plants. A Project, funded by Ecopneus, the non-profit consortium for the tracking, collection, processing and final destination of end-of-life tyres (ELT) created by the major manufacturers operating in Italy, and developed by Vie en.ro.se. ingegneria, was launched in 2014 to analyze the effectiveness of these building materials and systems, with particular attention to the solutions that use recycled rubber dust.

The project has been structured through various studies and activities, including research and measurement campaigns performed in laboratories and on field. During the various phases, the acoustic, thermal and structural properties of the materials have been considered and analyzed. Three volumes have been published reporting the main results of the study.

The first volume regards acoustic, thermal and structural properties of materials: it reports a typological study and cataloging of building products using recycled materials, divided by categories of use like resilient floors, anti-vibration materials, materials for acoustic insulation of walls, machineries, etc. The volume deals with the typical applications of these materials and building systems and concludes with summary data and tables on effectiveness of recycled products.

The second volume deals with the installation of recycled rubber insulators. It is a rational collection and analysis of manuals for the installation of products in the various typological categories defined in volume 1. In order to take in account the peculiarities of rubber-based products compared to other products, further study was carried out by comparing with some of the major companies involved in the study who have made available their work experience in the field over the years. The main topics are insulation of horizontal partitions of a building (mixed floors, wooden floors, raised floors, countertops, terraces, stairs, etc.), insulation of vertical partitions of a building (hollow space, wall plating, wooden walls); insulation of foundations of a building; insulation of building's facilities (continuous and discontinuous operation).

The third volume deals with the performance of rubberized insulators, defined by the collection of experimental data obtained from on field tests. Performances measured in typical scenarios were compared with the values obtained from calculations in order to evaluate the reliability of the numerical predictions with respect to the experimental values. In Fig.4 the covers of the three volumes reporting the results of the project are shown.



Figure 4: Three volumes reporting the results of the Project Ecopneus - Vie.en.ro.se.

EXAMPLE OF HOLISTIC DESIGN OF BUILDING – THE RISPESCIA AUDITORIUM

One of the most demonstrative cases that has been implemented in the frame of the project is the acoustic requalification of the Rispeccia Auditorium, located in a church, transformed in a multipurpose hall, for conferences, concerts and other events. In the original scenario the high reverberation time made any perceived sound confused and scarcely intelligible. The goal of the project has been to create an acoustically comfortable and versatile space, provided for different types of functions. Solutions have been designed by choosing products that results environmentally sustainable and fully respectful of the architecture of the church as well.

The Legambiente Auditorium, located in Rispeccia, western Tuscany, in the area of the National Centre for Sustainable Development "The Sunflower", was a church with a volume of approximately 1300 m³, characterized by the presence of highly reverberating finishing materials

and reflecting furniture (marble floor, plastered walls, stone in the altar area, cover bricks in the soffit tiles, wooden exterior carpentry and single glazing, wooden interior doors, metal benches drilled). This aspect, along with the major negative one, represented by volume, determined conditions of perceived acoustic discomfort that made difficult to use the hall for events including listening of speech and music. The church, or parts of it, weren't easy to use neither for simple exhibitions, lectures and other cultural events, due to the mentioned difficulties in perception of sounds and words in such a reverberating scenario.

Nevertheless, the church has regularly been one of the venues of Festambiente, the Italian National festival of the environment, full of cultural events on environmental issues. Festambiente takes place every year in August, more generally, the church hosts throughout the whole years many events and plays different functions, including conference room, workshops, exhibitions, theatrical performances etc.

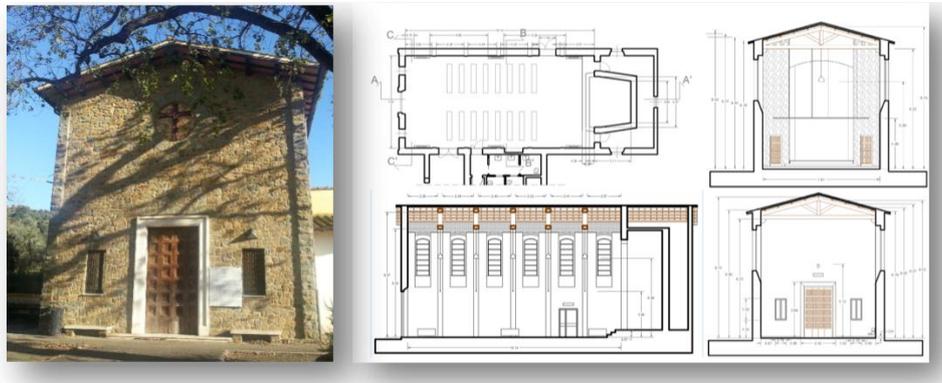


Figure 5: The church of Risposcia. facade, plan, elevations and sections.

All these destinations and functions have been taken in account as reference targets for the design of acoustics correction reported here. As shown in figure 1 the church has a rectangular plant of about 8 x 19 m and variable height from a minimum of 8.86 m to a maximum, in correspondence with the ridge line, equal to 9.92 m. The cover is made of two layers supported by wooden trusses. The room is equipped with an altar area currently used as a speaker zone when used for conferences, and as stage for concerts and plays. The plastered masonry walls are provided of windows (1 x 2.82 m). The bottom wall has a large entrance with 1.90 x 3,50 m wooden door of and two 0.78 x 1.50 m windows.

The 3D model of the church has been created making use of Ramsete© 2.5 software. The calculation parameters for the simulations aimed at the validation are shown below:

- Number of tracked pyramids: 8 x 210;
- Temperature: 20 ° C;
- Humidity: 50%;
- Diffraction: 2;
- Number of reflections after which the software randomizes: 4;
- Source type: omnidirectional.

The model has been calibrated by comparing the reverberation times measured in significant environmental points with the simulated reverberation times in the same locations. Some pictures of the modelling phase are reported in figure 3.

The good validation of the model has been proved by observing that deviations in absolute value of the measurement and simulated average reverberation time data are lower than 0.1 s.

In Fig. 6 the ante operam configuration as implemented in the model, is shown.

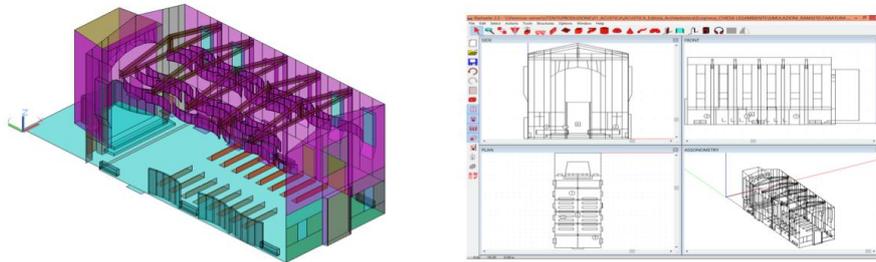


Figure 6: 3D model of the church in the ante operam configuration.

The main objective of the acoustic project was to create a sound comfortable and versatile environment for the different types of expected functions. This goal has been reached through the creation of variable solutions, able to guarantee for each intended use a proper acoustic performance.

The proposed acoustic solutions have been designed keeping in mind the virtuous constraint of sustainability for all selected construction materials and artefact in order to create a space that is eco-compatible and aesthetically attractive as well.

Only natural materials have been used, being them recycled and/or recyclable (plants, wood, recycled rubber from discarded tires, polyester from recycled PET bottles).

The project of acoustic correction of the church involved design and construction of three integrated solutions summarized below:

1. sound-absorbing evergreen plant coating for the improvement of absorption on the back wall of the church;
2. sound absorbing curved acoustic panels suspended from the ceiling (36 baffles arranged in parallel rows);
3. mobile network of double-face reflecting/absorbing panels on wheels for acoustic separation in different configurations of sub-areas.

Depending on their position and side, the reflecting/absorbing panels curved panels can perform a double function:

- sidewalls lining panels that, depending on the side facing the interior of the church, are sound-absorbing or reflecting and diffusing sound;
- acoustic separation elements between different sub-areas of the hall.

Specifically, panels have radius of curvature of 3.5 m, height 2 m and a thickness of 106 mm, some with sound absorbing concave side and other with sound absorbing convex side.

The stratification of panels is made by:

- a layer of recycled rubber from discarded tires, which provide mass to the system, 10 mm thickness and density 750 kg / m³;
- double wood panel, thickness 8 + 8 mm, which provides the curve to the panel;
- double polyester fiber panel, thickness 40 + 40 mm and density of 40 kg/m².
- coating on both sides, including the thickness, of a lightweight fabric in polyester fiber, weight of 150 g/m².

The system is supported by a wooden structure and floating through the use of wheels provided of brake system for a total weight of about 80 kg. Since the product has been designed "ad hoc" the acoustic performance in terms of sound insulation and sound absorption coefficients has been estimated from similar products, since laboratory test reports are not available. In Figure 7 some design patterns of the three interventions and in figure 8 some pictures of the church are shown.

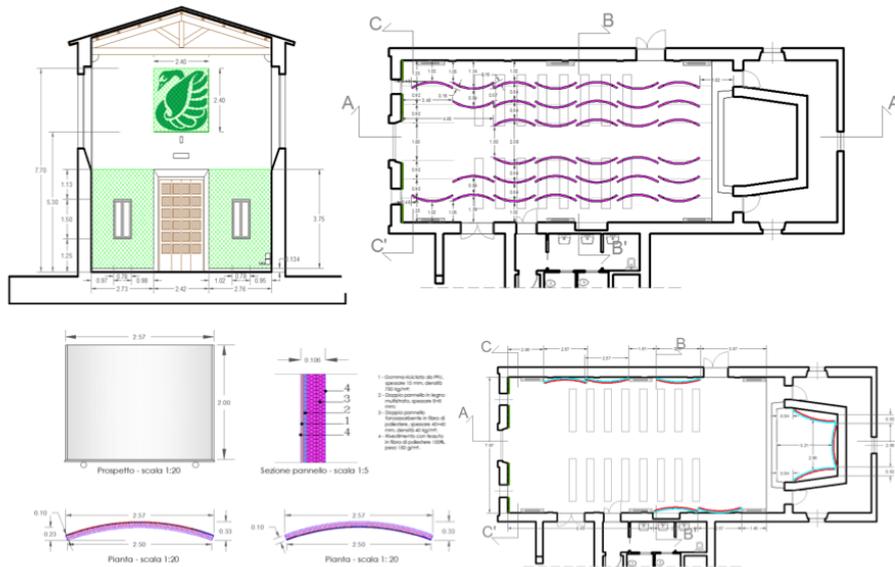


Figure 7: Design patterns of the three solutions



Figure 8: Acoustic solutions

The acoustic improvement of the church of Rispecchia has transformed it in a real auditorium and a multi-functional acoustic space as well. The reverberation time measured after design and construction shows full compliance with the project objectives, mainly aimed to create acoustic comfort conditions primarily in listening speech (conferences, lessons, workshops, theatrical plays, cinema, expositions, etc.).

The variable acoustics of the church, required to ensure optimal acoustic conditions in correspondence with the different uses is determined by the combination of three solutions and by the configuration of movable panels. Differences in the reverberation time variable from 5% to approximately 30% at all frequencies allow tailored acoustic configurations, depending on the intended use of the space (e.g. for music, a reverberant acoustics of the room can be obtained rotating double-face movable panels in the reflecting side or excluding one or more of them from the room. The distribution of the noise levels in the whole church has resulted very homogeneous, with maximum differences between the position nearest and farthest from the sound source placed on the altar contained within 3 dB(A).

Finally, for sub-areas, double-face panels, positioned in agreement with the proposed schemes for workshop configurations, determine high levels of attenuation, in comparison with basic configuration, with values that exceed 10 dB(A) in the most screened areas.

CONCLUSIONS

Sustainability takes into account how we might live in harmony with the natural world around us, protecting it from damage and destruction. Sustainability and quality of life must be considered by those who administer and plan cities in all their aspects, considering open spaces and built environment. Urban action plans and design of new buildings should follow an encompassing view, based on the knowledge of nature, functions, and properties of the components, their interactions, and their relationship to the whole.

The professional acousticians can give qualified contributions for effective strategies and solutions for noise control, public health, land use and preservation.

In this paper the holistic approach to plan and design has been shown and referred to acoustic design of urban areas and buildings: it is based on the principle of maximize the pleasantness of places and the global satisfaction of people, considering sustainability like a positive karma that can stop the planet's degradation and the discomfort of its inhabitants.

An example of holistic urban planning has been presented: the noise low emission zones designed in the frame of Life MONZA project. An example of holistic design of building has been reported as well: the Rispecchia auditorium, where an acoustically comfortable and versatile space, has been created choosing environmentally sustainable materials and designing solution and fully respectful of the architecture of the church as well

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