National Etruscan museum “Pompeo Aria”, Marzabotto, Italy: an example of an integrated approach to sustainable museums design

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ABSTRACT: The paper focus on the retrofitting and enlargement of the National Etruscan Museum “Pompeo Aria” in Marzabotto Italy. The museum has been selected as case study of a set of EU Projects about the subject of sustainable architecture and energy efficiency; now it’s a demonstration project of “MUSEUMS” EC FPV Project. Global retrofitting and extension of Marzabotto’s museum are based on an integrate approach which foresees environment protection and rational use of resources as main targets. The project pays attention on balancing bio-climatic and passive solar techniques with active systems, in order to create adequate climate and environmental conditions for preventive conservation of exhibits and, by the way, to offer the best comfort for employees and visitors.

Conference Topic: 2 Design strategies and tools
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1. INTRODUCTION

Museums are a very special case of building typology which combine the original purpose of preserving and showing parts of the human heritage together with many other functions. Today’s museums tend to be multi-use centres mixing together culture, education and recreation.

Design of new museums and retrofitting of existing ones represent a great chance to apply sustainable principles and transform the building itself in an “exhibit to show” creating a great occasion to teach and promote the rational use of energy and ecological awareness.

Indoor climate control inside museums represents a complex theme as it implies the satisfaction of two different kinds of requirements:
- appropriate conditions for preventive conservation;
- appropriate conditions for human comfort.

In a museum, and more generally in any space devoted to exhibition, you can not design inside microclimate without considering how this will act on the exhibits. The best conditions under which each object of art should be exhibited in terms of lighting and climate control are a matter of a peculiar branch of the conservation science called preventive conservation. Museum conservator is the person in charge to pursue preventing conservation targets by selecting best conservation conditions for each specific exhibit.

The real challenge of an ecological conscious design approach based on bioclimatic principles is to combine passive strategies with active ones in order to create the best indoor conditions suitable both for conservation and for comfort aligned with following energy saving targets. This goal requires a defined design method to manage such complexity and handle the different disciplines involved [1].

The retrofitting and enlargement of the National Etruscan Museum “Pompeo Aria” in Marzabotto Italy is one of the demonstration projects of “MUSEUMS” EC FPV Project [2].

The solutions proposed for the case study have been investigated during the implementation of two other Projects carried out in the framework of EC Programmes on energy savings [3].

2. MUSEUM AND ARCHAEOLOGICAL SITE

Figure 1: View of the museum during the construction of the new exhibition hall. (building C).
Marzabotto museum “Pompeo Aria” (Fig. 1): is a significant case study as it is representative of more than 3000 small-middle sized museums located in Italy [4]. Such museums are mostly public properties and generally host exhibits coming from the site. In a lot of cases their indoor environmental quality as well as the energy performance, is poor.

Museum is located by an Etruscan settlement of the 6th century B.C., close to Marzabotto (Bologna) [5]. The museum complex can be divided into three different parts partially connected. Building (A) is formed by a two stories and square-based building made at the end of the 19th century that has at the ground floor the main entrance and an exhibition space and at the upper floor the keeper’s flat. Close to this building a long and narrow one (extension of 1958) (B) starts; it’s oriented north-south with an arcade on its western façade used to exhibit some archaeological pieces. By south side we find another long building (extension of 1979) that at the beginning of the project hosted toilets, a boiler room and a little warehouse (C). During the renovation such building has been demolished and built up as new for exhibition purposes. Near to that building a small construction hosts a cafeteria, while some offices and new storages are located in an old rehabilitated barn by the area (Fig. 2).

3. DESIGN: TARGETS AND CONCEPTS

The extension, and retrofitting project for the Marzabotto’s museum “Pompeo Aria” (Fig. 3) are based on a sustainable approach which is the result of common-sense and responsible use of energy resources and environmental conservation [6]. This project pays attention on balancing bio-climatic and passive solar techniques with active systems, in order to create adequate climate and environmental conditions for preventive conservation and, by the way, offer to visitors and workers a good condition to stay in [7].
Design general targets fit with Project MUSEUMS ones:
- apply and test new and innovative technologies to advance architecturally integrated environmental control strategies;
- demonstrate that energy efficiency and sustainable museum buildings can fully meet the architectural, functional, visual and thermal comfort, control and safety requirements;
- achieve total energy spared of over 35% in retrofitting and 40% in new projects and reduce CO2 emissions by over 50%;
- contribute to the preservation of European cultural heritage and to the acceptance of innovative and renewable technologies in public buildings.

From a functional point of view a specific target is to obtain out of the three distinct buildings one single complex museum in which it is possible visiting the interior halls as well as watching out and appreciate the archaeological site. For this reason the link with the outside is obtained thought solutions that allow to have a proper view of the archaeological area and at the same time to host outdoor exhibition spaces. The walkway brings visitors from inside to outside, so they can have a whole sightseeing of the ancient village after have admired Etruscan masterpieces found in it. The totally re-built exhibition hall faces on south side. The southern façade is protected, all over its length, by a timber balcony which has specific solar control functions. Such balcony works also as an exhaustive view-point for the visitor who wants to walk upstairs and have a total perception of the area, while he is going to the multifunction room placed at the upper level of the corner building. New exhibition hall is divided into three northern exhibition spaces by heavy mass segment of walls and show cases. At south a distribution area links them.

The difference between exhibition and distribution space requires the satisfaction of different requirements. While exhibition rooms need a stable and more controlled climate with uniform and reduced daylight levels, the corridor allows more variation even in daylighting in order to create emotion and sense of link with the outside, through the view out.

4. THERMAL CONTROL

The passive techniques are applied in this bio-climatic design both enhancing solar gains and reducing heat losses through the envelope during the winter time and controlling the sun radiation during summer time (Fig. 4). In the new exhibition hall and the multifunction room, this process is obtained by a correct placement and sizing, but also a right orientation, of the glass surfaces together with fixed external shading, placed outside the openings and connected to the wooden balcony. This horizontal shading controls the solar radiation in every season of the year according to indoor micro-climate and energy savings requirements. In order to avoid summer over-heating, the roof tilt is faced to the north. The walls have a high thermal mass and insulation. The air intakes provide a good cross ventilation, and some openings in the counter roof improve the stack effect (Fig. 5). Air extractors equipped with fans are situated on the covering and through a specific control system they supply night ventilation during the summer, free cooling during intermediate seasons and air changes.

Solar radiation control, high thermal mass, ventilated roof and natural night ventilation aim to avoid any air conditioning system.

The heating system consists in radiant heaters located underneath the floor. They work with low temperature water supplied by a high efficiency condensation boiler. The energy plant is also arranged to insert Photovoltaic panels into the balcony in the future. They will be grid connected and produce electricity for interior lighting and fans.

The building ability and passive strategies to mediate and control climatic agents have been carefully investigated by means of dynamic simulation tools (Esp-r, Summer). Simulations have proved that through the comprehensive strategy is possible to get acceptable indoor thermal conditions during summer without any active systems. This has been especially
possible because exhibits don’t ask any severe conservation requirement (Fig. 6).

5. DAYLIGHT

In the south-facing façade, the external shading device calibrates interior daylight. Such device is combined with internal curtain in order to diffuse sun light coming from outside.

The sun shading device protects the windows from summer radiation. In winter time, the system allows solar gain and natural light control (Fig. 7).

The exhibition area has a controlled amount of daylight for exhibit preventive conservation purposes. The walkway has higher illuminance levels because of openings towards the archaeological site and lighting redirecting systems hanged over the space.

Parting walls shields daylight coming from outside to reduce glare and provide a comfortable visual environment.

The artificial lighting system integrates daylighting according to daylight amount and presence of visitors.

6. CONTROL SYSTEMS

Indoor climate control is obtained balancing passive strategies with active systems, trying in any case to get most advantage from the building bioclimatic concept. This implies that active systems have to be adjusted in order to consider as much as possible all the passive energy contributions: solar radiation, daylighting and natural ventilation.

The high efficiency condensation module boiler has a dedicated control system based on climate control. Such control directly regulates operation time and water temperatures using modulating gas flame controls. Each climatic zone has a thermostat connected to electric valves (on-off) which controls indoor temperature according to the set point.

Ventilation system is controlled both by CO₂ sensors for air quality and indoor/outdoor temperature sensors. Sensor control, together with a timer, control air changes, allow free cooling when suitable and night ventilation during the summer.

The distribution spaces lamps are controlled by illuminance sensors which turn on lights according to daylight availability.

Infrared sensors inside the museum detect people and turn on showcases lighting system.

7. ACOUSTICS DESIGN

Indoor acoustical conditions have been carefully designed to guarantee comfort conditions even in crowded situations. The reverberation time is controlled in order to allow hearing guides when in one volume there are two visiting groups at the same time. For that purposes acoustic absorption characteristics of the materials have been deeply investigated.

A special porous acoustic plaster is used in the counter roof element. Such device permits also to diffuse visible light.

8. MATERIALS AND BUILDING TECHNOLOGIES

The choice of technologies and materials has been performed considering both the environmental consequences associated with the acquisition, transportation and manufacturing of materials prior to construction and health effects for inhabitants, in the form of emissions of noxious substances from building materials.

The final choice has also considered locally produced materials to reduce transportation energy use and pollution impact and materials that can be re-used or re-cycled at the end of their use.

Basic materials used (Fig. 8) are porous clay blocks (obtained using wood sawdust), wooden fibres insulation panels, natural lime plaster made of hydraulic natural lime and foam silica. Roof, and balcony structure are made with non-treated timber, coming from local controlled cultivations (Fig. 8).

During the construction activities a workshop was organized on the construction field hosting the
presentation of a producer of natural and sustainable coverings and finishing building materials. The workshop was opened to students, experts and museum builders and it included different demonstrations. This has resulted very useful in enhancing the use of such materials and enabling the museum builders to check and to be trained on how to use them.

9. CONCLUSIONS

The museum is up to now under construction (Fig. 9). The timber balcony and indoor finishing should be completed before the end of 2004. According to MUSEUMS Project purposes the overall strategy and specific solutions applied in the enlargement and retrofitting of the museum of Marzabotto have to be easily applicable and extended to other cases. Hypothesis verified through simulations during the design phase will be tested under real conditions by monitoring main environmental and energy performance indicators.

REFERENCES AND NOTES

[1] Such theme has been the object of a research activity carried out by the authors about indoor climate control inside historical buildings used as museums: "Progetto Strategico C.N.R. per il Recupero Edilizio" (1989-1993); "Progetto finalizzato C.N.R., Tecnologie, Beni Culturali e Ambientali - Caso di studio la Galleria degli Uffizi a Firenze" (1998-99); "Operative and methodological instruments for the restructuring of the system of museums and libraries of St. Petersburg’s University", EU - INTAS (1995-1998).

[2] The Project “MUSEUMS – Energy and Sustainability in Retrofitted and New Museum Buildings” (contract duration 2000-2004, contract n. Nne5/1999/20), coordinated by Meletitiki Tombazis, Athens, aims to define methods and procedures for an integrated approach to the sustainable design of new or retrofitted museums. Methodologies and best sustainable practices are applied in 8 demonstration projects located all around Europe. The eight cases were selected with the criteria of being representative and typical or generic, while having at the same time a distinct character and a unique place among other similar cases.

Ph.D. eng. Angelo Mingozzi is the scientific responsible and coordinator of the cross disciplinary design team of the demonstration project of Marzabotto and leader of the “Horizontal activity” about “indoor climate”. Some more information on the project are available at: http://www.sustainable-european-museums.net/.


This has been the occasion to orient design choices starting from an accurate analysis of the existing environmental and energy performances, carried out through surveys, summer and winter monitoring, visitors questionnaires, etc.... Design retrofitting hypothesis were verified with simulation tools to compare different strategies and perform cost benefit analysis.


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