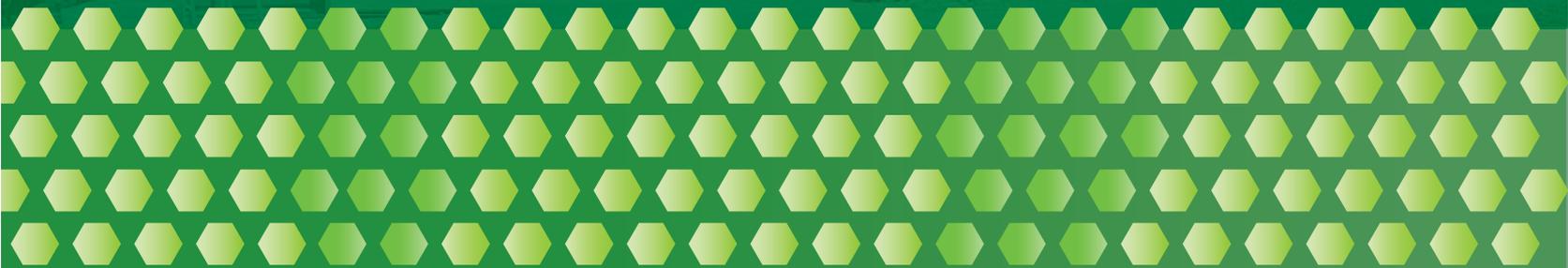


Passive Cooling



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Teenergy - Despina Serghides
Cyprus University of Technology

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Introduction: Passive Cooling

The Public Conference and the International Workshop on Passive Cooling were organized by the ARPA Sicily (Environmental Protection Agency of Sicily) and the Province of Trapani.

The aim was to involve all the stakeholders (politicians, companies, students, teachers and school managers) on passive cooling techniques to improve the indoor comfort in the hot Mediterranean climate and at the same time achieve energy saving, for reducing costs and energy consumption in the school buildings.

The Public Conference took place in the University of Trapani on the 24th of February, while the International Workshop took place in the ARPA Sicily center in Palermo on the 25th of February.

During the Public Conference in Trapani there were two main technical speakers. The architect Rainer Toshikazu Winter (ABITA, Inter University Research, University of Florence) showed examples of “High Energy Efficiency School Buildings”; the architect Rosella Carlino (PhD in Building and Environmental Recovery, University of Palermo) showed examples of “Passive Cooling in the History of the Mediterranean Area”.

During the International Workshop in Palermo the architect Marco Sala (ABITA, Inter University Research, University of Florence) introduced the “TEENERGY Schools - Energy Audit Methodology”. The architect Francesco Tomaselli (University of Palermo) illustrated “The Zisa Castle of Palermo”, the architect Carlo Brizioli (University of Rome, Ludovico Quaroni) presented “Cooling-Retrofitting Strategies for Public Educational Buildings”, the engineer Christian Ghiaus (INSA Lyon, France) spoke about “Energy Efficiency in Public Buildings, Analysis Methodology and Technical Improvements”.

In this brochure the synopses of the presentations of the keynote speakers of both the conference and the workshop are presented.

TEENERGY SCHOOLS, a programme co-financed by the Regional Development Fund of the European Union, targets the improvement of Energy Efficiency in Public School Buildings in the Mediterranean Area covering 5 different territories and 3 typical climate conditions referred to coast, mountains and plains. The Partnership is composed by 8 partners from the following 4 countries:

Italy: Province of Lucca (Lead Partner) ABITA international research center Florence, Province of Trapani, Regional Energy Agency of Sicily, Cyprus: Cyprus University of Technology, Greece: Prefecture of Athens, NKUA IASA University of Athens, Spain: Regional council of Granada.

The project aims at solving 2 common problems of the Mediterranean Area: The lack of energy saving benchmarks targeted specifically to South European climate conditions and the low energy efficiency of actual School Buildings, Teenergy Schools will set up an Action Plan and a Common Strategy aimed to reduce energy costs and consumptions in public secondary school buildings.

The international Partnership is actually collaborating in research and concept design regarding: energy saving techniques, employment of renewable energies, integration of innovative materials, improvement of heating systems, strategies for passive cooling. Teenergy Schools is elaborating a Benchmark Guide based on data from an Energy Audit, that each Partner will conduct in order to provide representative values permitting to compare each School Building’s actual energy performance throughout the Mediterranean Area. 12 Pilot projects will be developed following the indications of the Action Plan - www.teenergy.eu

Despina Serghides (Cyprus University of Technology)

Energy Performance and Retrofitting for a High-school in Province of Lucca

Marco Sala (ABITA, Inter University Research, University of Florence)

In collaboration with Arch. Rosa Romano ABITA inter university research center
Assistants: Arch. Marta Pesamosca Ing. Claudio Latini
Thermography: Cristina Carletti and Fabio Scieurpi TAED.

This script describes the energy performance and retrofitting scenario for a Secondary Highschool in Province of Lucca, conducted in the "I.T.C. Piaggia " (Viareggio), in the climatic area "coast" build in 1960.

The strategies for the energy audit conducted on this school building were the following:

- 1) **Obtain information regarding the typology and structural characteristics of the building. Analysis of building plans (provided by the research group)**
- 2) **Survey aimed to identify the main and most significant views of the building to be analyzed by infrared thermocamera (infrared spectrum) and confronted with normal photos (visible spectrum)**
- 3) **In parallel, detection of micro-climatic indoor and outdoor conditions**
- 4) **Analysis of acquired images on PC through dedicated software;**
- 5) **Analysis of thermal imaging and detection of major problems related to the building.**

The following main aspects came out as first results of the Audit:

- **Reinforced concrete structure with brick fillings presenting large surfaces exposed to the outside with no thermal insulation thus creating important thermal bridges.**
- **The flat roof is done in brick and concrete flooring with very low insulation characteristics**
- **Excessive overheating in the summer period, partly due to the lack of sun shading devices**
- **Metal framed windows lacking double glazing**
- **Over dimensioned openings considering floor area to be illuminated**
- **Heating system insufficient: radiators integrated in external wall and uninsulated tubes creating substantial heat losses and phenomena of condensation**
- **Low energy efficiency of artificial illumination**

The thermography as strategic instrument within the energy audit has given useful inputs for the diagnosis of problems related to the energy performances of the building. It has helped to localize general heat losses and problematic junctions such as punctual



cd/m2
 272.040
 243.404
 214.768
 186.132
 157.497
 128.861
 100.225
 71.589
 42.953
 14.317

thermal bridges due to incorrect assembly of building components or the lacking of insulation.

Considering the actual energy consumption of the building, the overall project scenario, foresees the following improvements:

- **High energy efficient external insulation with natural, hygroscopic materials avoiding heat losses and condensation**
- **Natural ventilation systems: New windows capable of giving high insulation standards and guaranteeing natural ventilation throughout “intelligent Window technique” for high thermal and hygroscopic indoor comfort**
- **Solar control using sunshading devices against glare and overheating in summer ensuring a good thermal-, air- and visual quality inside the classrooms**
- **Passive Cooling techniques: Night cooling throughout sensor-controlled openings during the summer.**
- **Control of natural and artificial lightning with LED based dimming technology.**
- **Innovative heating system based on low temperature radiation elements (floor or walls) and high energy efficiency boilers**
- **Use of renewable energies (PV panels)**
- **Rainwater use in roof collectors for toilet flushing in a dual system avoiding electric energy for pressurization of water.**

CONCLUSIONS

There is an increase of public awareness, of standards and regulations, of research and new technologies and of European funding for Green Architecture. Common sense energy management is combined with energy production and energy efficiency, sustainability and well being.

WE ARE HEADING IN THE RIGHT DIRECTION!

1: “I.T.C. Piaggia “ (Viareggio) good natural lighting conditions but bad energy efficiency of windows

2: “I.T.C. Piaggia “ (Viareggio) staircase: exaggerated single glazed surfaces with no sunshading devices

“I.T.C. Piaggia “ (Viareggio) secondary high school outside thermographic captures showing important heat losses in windows and structure

Free-running building temperature and HVAC climatic suitability

Christian Ghiaus, INSA-Lyon

Decisions taken in the early stages of architectural design have an important impact on energy demand and efficiency. In this design phase, architects and engineers need to manipulate common concepts that reveal the influence of building, comfort criteria, and climate on energy consumption. Such a concept is the indoor temperature of the free-running building, which, combined with comfort criteria and climate, allows to assess the relative weight of heating, ventilation and air conditioning systems in energy budget. Based on this concept and on the probabilistic distribution of the outdoor air temperature, it was developed a method that indicates the heating and cooling needs, and gives a measure of the energy saved for cooling when ventilation is used. This method also gives the load for which the mechanical systems should be designed to obtain maximum efficiency and shows the feasibility of stack-induced natural ventilation. Weather data needed for this method are available in public domain from satellite investigation. The method can be applied when buildings similar to existing ones are constructed in a new location, when existing buildings are retrofitted or when completely new buildings are designed.

A free-running building does not make any use of mechanical heating or cooling. Its indoor temperature, T_{fr} , depends on the outdoor temperature and the total heat gains (from sun, occupants, lights and so forth); furthermore, we will consider that the free-running temperature is defined for the minimum ventilation rate needed for indoor air quality, which implies that the building is tight. The indoor temperature of the free-running building may be used instead of balance point temperature in energy estimation methods such as degree-days or bin methods. Using the indoor temperature of the free running building, the outdoor temperature and the comfort zone, the domains for heating, cooling and ventilation can be defined (Fig. 1). By multiplying the temperature difference between the free-running temperature and the comfort limit temperature with the number of occurrences of this difference, we obtain the degree-hour or degree-day temperature, depending on the sampling time used (1h or 1 day).

It demonstrates that the dynamic values can be used to estimate the energy load curve, that this curve may be applied to calculate the energy consumption and that the free-running temperature is an equivalent form of the heating / cooling curve (Fig. 2 and 3). Similar to the load curve, the free-running temperature can be determined experimentally. The main advantages of using the concept of free-running temperature are that

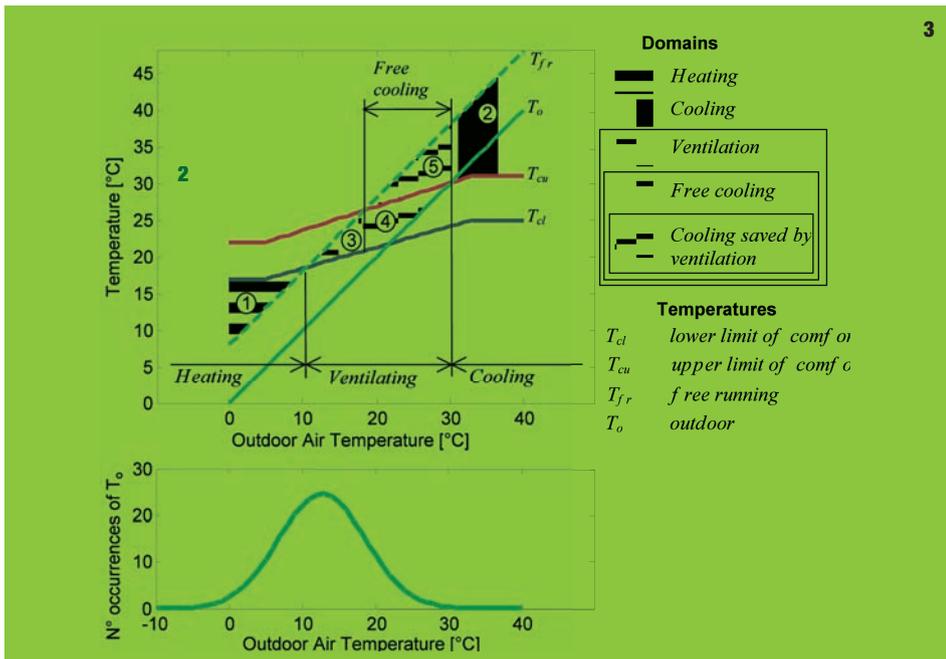
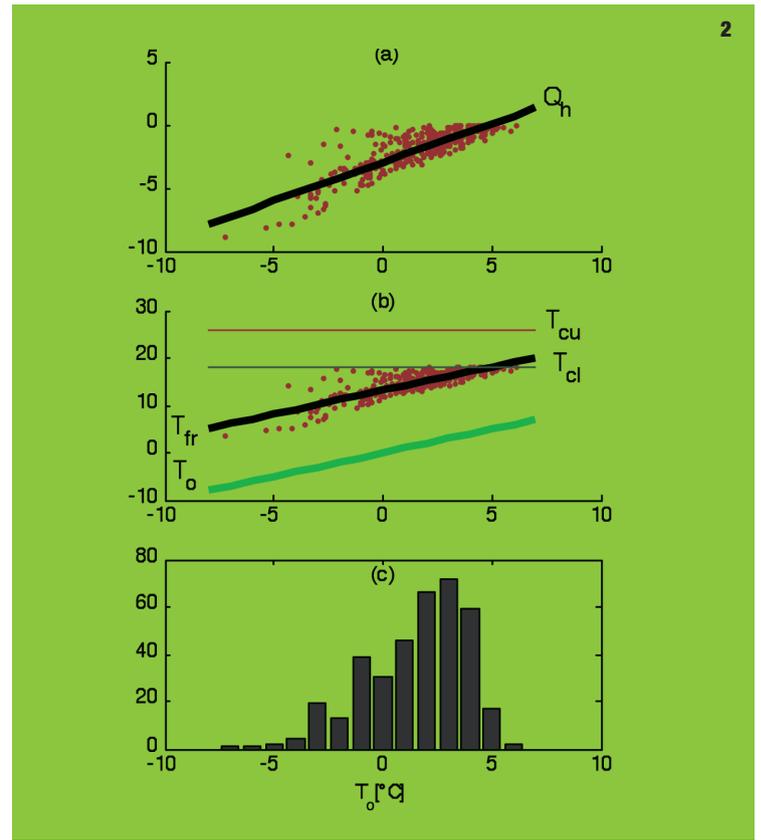
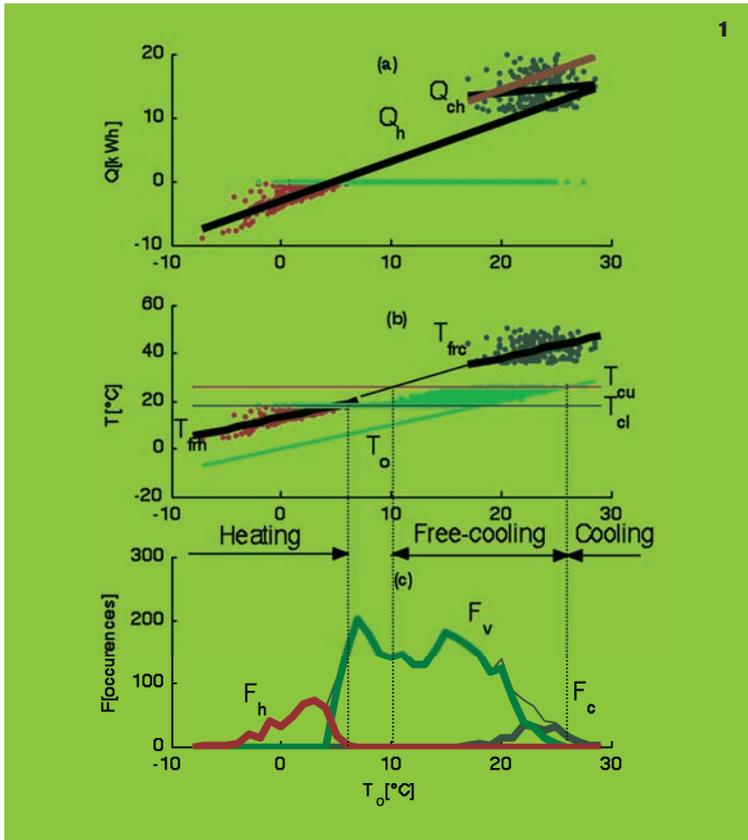
- 1) the dynamic behavior may be described by steady-state concepts,**
- 2) the whole range of building operation (heating, ventilation and cooling) is described by a single concept, and**
- 3) the thermal behavior of the building, the comfort and the climate are decoupled.**

methodology for integrated conservation of existing buildings

Definition of new building models able to meet changing customers profiles, rising standards of indoor comfort in hot and cold season and the necessity of a more aware management of the available energy resources

Valorization of the existing building heritage through high-quality retrofitting based on the improvement of safety standards regarding earthquake risk and energy efficient performances;

Developing and testing innovative solutions in an “open-catalogue” able to address both technical and architectural quality.



1: Energy load and free-running temperature for heating and cooling: a) Heating load; b) Free-running temperature obtained from heating load; c) Frequency of occurrences distribution of outdoor temperature.

2: Energy load and free-running temperature for heating: a) Heating load; b) Free-running temperature obtained from heating load; c) Frequency of occurrences distribution of outdoor temperature.

3: Heating, ventilating and cooling domains.

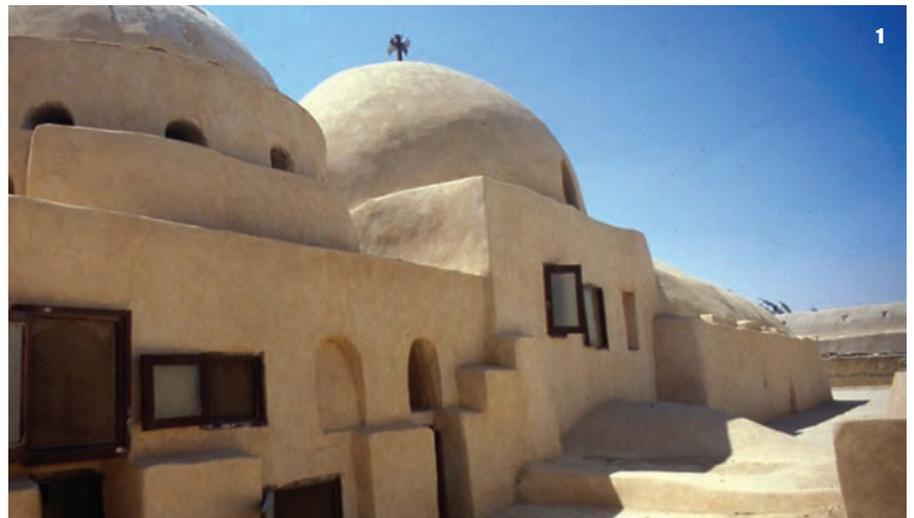
Passive cooling in the Mediterranean Area

By Rosa Carlino (Palermo Univerity)

Mediterranean vernacular Architecture reflects the wisdom of our predecessors to master the climate, to build buildings and to develop cities in full synergy with the surrounding environment. Evidence of this is still found in wind towers, solar chimneys, sirocco rooms, recessed structures below grade, “dammusi” (the architectural symbol of Pantelleria), courtyards and streets channeling prevailing summer breezes; or in building elements for solar or wind protection such as porticoes, loggias, cloisters, patios, etc. Passive cooling techniques are still present in many Mediterranean countries (Greece, Turkey, Syria, Egypt, Morocco and Sicily) where we find autochthon architectural examples. We come across an outstanding example of passive cooling walking through the intricate framework of Emporeion in Greece (picture no. 1) or visiting the underground cities carved in rocks like Aciksaray and Derinkuyu in Turkey (picture no.2). In the village of Sronj the cone-shaped houses allow the inner wind fluxes (picture no. 3). In the historical centre of Damascus we could explore a traditional architecture with numerous examples of passive cooling; streets facilitating natural ventilation, shaded courtyards and special screening of openings with mashrabiya and Kullaleya (pictures no. 4 and 5). In the Copt monasteries of Wadí El-Natron, northern Egypt, the peculiarity of the strual elements corresponds to their environmental features (picture no.6). Inside the Moroccan Qasbas of Taourirt in Quarzazate, there exist ventilation chimneys still in use (picture no.7) whose technique is similar to those in the underground cities of Cappadocia. There is an example of sirocco room in Villa Naselli Agliata, Palermo, incorporating a wind tower with a truncated-conic shape (picture no. 8), The Norman building of Zisa in Palermo is also a representative example of passive cooling/ventilation system moderating the micro-climate using only natural means during the hottest months of the year.



- 1: Ventilation channel morocco gasba Tourit
- 2: Underground ventilation channel in Villa Amblesi Naselli - Palermo
- 3: Fenestration treatment in Damascus, Syria
- 4: Passive Cooling in the streets of Emporeion, Santorini, Greece
- 5: Ventilation channel morocco gasba Tourit





Zisa castle, an example of bioclimatic tradition

Antonio Tomaselli (University of Palermo) by Sabrina Buttitta (ARPA Sicila)

ARPA Sicilia asked the professor Antonio Tomaselli to illustrate the Zisa Castle of Palermo on a guided visit. The professor, who was in charge of the restoration work carried out on the castle, described how its ventilation system anticipated by approximately 850 years the technological solutions which modern architecture adopts in today's buildings.

The Zisa castle is characterised by its Moorish architectural tradition from North Africa, which during the expansion of the Islamic culture influenced the entire Mediterranean area. The used technological solutions aimed to achieve indoor comfort for the Mediterranean climate.

The castle dates back to 1164 and took only a few years to build. It is a large parallelepiped edifice with a perfectly symmetrical rectangular plan. On the ground floor there is a main entrance hall located in the centre, enhanced with a fountain. The two upper floors, intended for male and female quarters, are crowned by a terrace. The terrace originally had an opening in its centre, allowing rain water to fall into the watershed located on the second floor of the castle which was then channelled into conduits dug into the ceilings.

A large tank is situated in front of the castle to collect the water flowing from the internal fountain. This large quantity of water, besides hosting a large number of colourful fish and water plants, also had a bioclimatic function. The parallelepiped edifice was completed with two lateral towers jutting upwards from the outline of the building and house the "ventilation chimneys" connected to all three levels of the structure.

The main facade of the edifice facing north-east together with three large openings suggests the desire to take maximum advantage of the benefits the sea breezes.

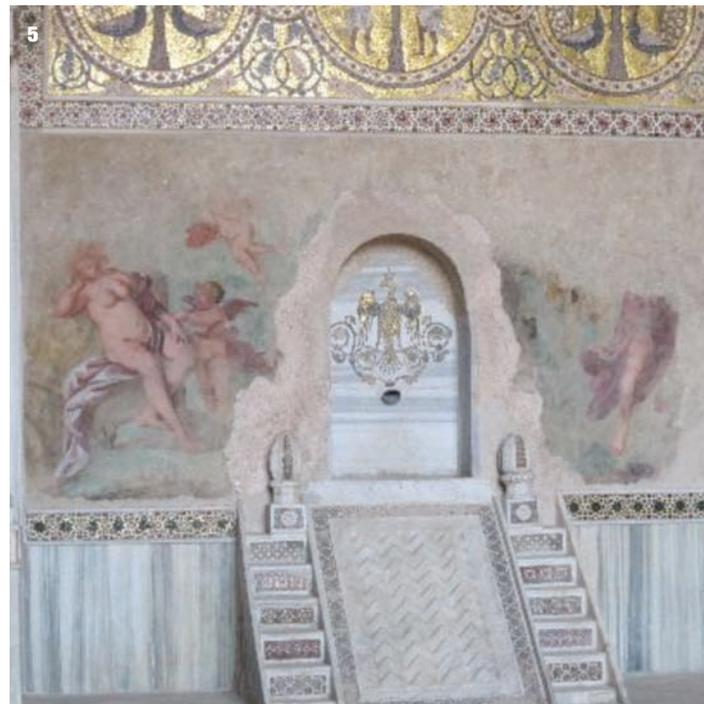
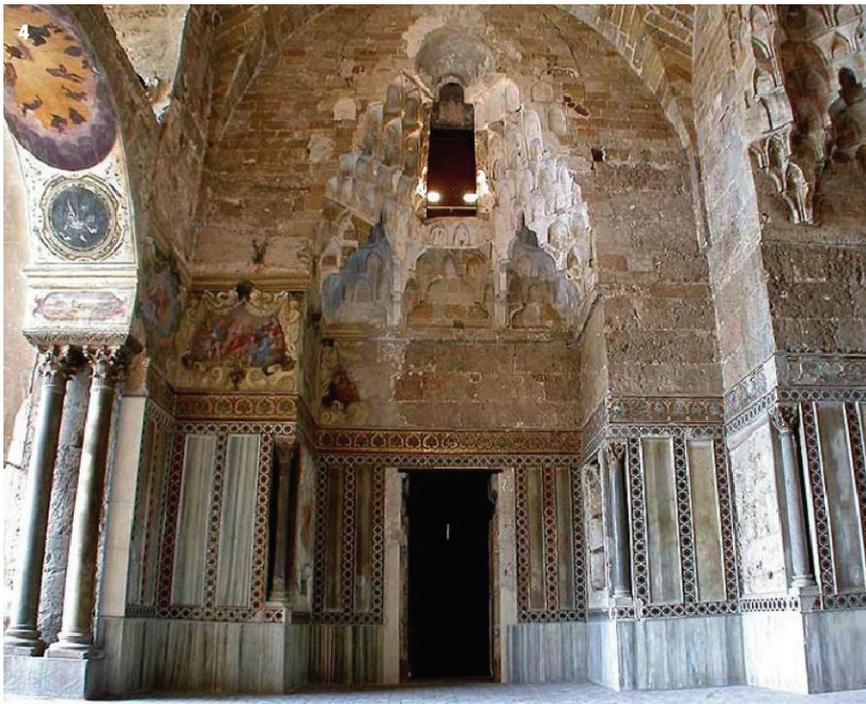
The natural ventilation inside the castle was achieved by five main elements: the large pool in the garden at the front, the fountain located on the ground floor, the two ventilating chimneys and the large humid sheets hung beneath the ceilings of the various rooms on the upper floors.

The sea breezes from the port of Palermo, were cooled over the pool. The air entered through the large entrance portico and it was further cooled by the central fountain. As the cooled air began to heat up, it flowed towards the upper floors aided by the chimneys. The movement of the air was further promoted by the mass of the chimney walls which, heated outside by the hot rays of the sun, produced a vortex of air inside. The small vortexes caused the air to rise.

Thus, the air circulated throughout all of the rooms. The system was assisted by the presence of a small single hole above each door of the various rooms. This hole allowed the warm air to be recalled by the depression even when the doors were closed. The movement of the air mass continued following the principle of air convection. The remaining hot air was cooled by the large humid sheets hung from the beams and the fittings which continue to be visible today on the ceilings. These large sheets, which were dampened with cold water, covered the ceilings, acted as cold-hot exchangers, cooled the hot air which was stratified above returning it into circulation.



- 1: The lateral tower
- 2: The Zisa Castle of Palermo
- 3: Top view of the entrance hall
- 4: The entrance hall
- 5: A detail of the fountain of the entrance hall



Energy Auditing in the Majorana High School in Capannori, in the Province of Lucca

Rainer Toshikazu Winter (ABITA, Inter University Research, University of Florence)
& Rosa Romano, (ABITA)

In collaboration with Arch. Rosa Romano ABITA inter university research center
Assistants: Arch. Marta Pesamosca Ing. Claudio Latini
Thermography: Cristina Carletti and Fabio Scurpi TAED.

In the framework of the TEENERGY SCHOOLS' updating of the ongoing ENERGY AUDIT activities the ABITA inter-university research center has conducted the second series of analysis's regarding the secondary schools in the Province of Lucca, in the Majorana High School in Capannori, in the climatic area "plain". This was done in collaboration with the Laboratory of Environmental Physics for the quality of building of the Department of Technology TAED, introducing thermography as instrument for the visualization of heat losses within the building. These studies have given opportunity to verify and complete the methodology of the Energy Audit to be adopted throughout the partnership.

Particularly, the following problems have been encountered in the school building:

- **Over dimensioned openings considering floor area to be illuminated**
- **Single glazed, aluminum windows causing high heat losses**
- **Full brick walls with low insulation characteristics**
- **Uninsulated tubes of heating system causing ineffectiveness**
- **Condensation due to heat losses in wall and roof**
- **Low energy efficiency of artificial illumination**



2

The thermography has given useful inputs for the diagnosis of problems related to the energy performances of the building helping to localize heat losses and problematic junctions such as thermal bridges due to incorrect or lacking insulation.

Considering the actual energy consumption of the building, the project scenario, foresees the following improvements:

- **High energy efficient external insulation with natural, hygroscopic materials**
- **New Windows capable of giving high insulation standards and guaranteeing natural ventilation throughout “intelligent Window technique” for high indoor comfort**
- **Solar control against glare and overheating in summer ensuring a good thermal, air and visual quality inside the classrooms**
- **Night cooling throughout sensor controlled openings during the summer Control of natural and artificial lighting**
- **Innovative heating system based on low temperature and high energy efficiency**
- **Use of renewable energies (PV panels)**
- **Rainwater use in roof collectors for toilet flushing in a dual system avoiding electric energy for pressurization of water.**

3

1: Inside a classroom

2: Window placement for Daylight in classrooms

3: Majorana Institute in Capanori view of the windows with semiclosed shutters in order to avoid glare

Passive retrofitting strategies for school buildings in the Mediterranean area

Carlo Brizioli (University of Rome, Ludovico Quaroni) by Carola Arrivas Bajardi, ARPA Sicilia

ARPA Sicilia asked the architect Carlo Brizioli, tutor at the ITACA department of Rome University “Sapienza”, to illustrate the ‘passive retrofitting’ strategies for the school buildings in the Mediterranean area. The architect showed the case studies of the ITACA department on the field.

The “passive retrofitting” concerns energy efficiency and it consists in reducing the energy demand that will then be covered by “active” integrated systems which are powered, in so far as possible, by renewable sources. The passive strategy also affects the building morphology and the building envelope technology, offering an important occasion for the upgrading of the appearance of building structures.

The so-called ‘Mediterranean’ climate is a local variant of the temperate climatic zone which extends between the cold climatic zone and subtropical zone around the Mediterranean sea. The main characteristics of these types of climate is the presence of a dry and hot season during the summer months and a season which is moderately cold and humid during the winter season.

Improving the energy performance of a building located in these climatic conditions encounters contrasting requirements (summer/winter) that must be suitably reconciled in order establish the most convenient point of optimization.

The specific problems relating to Mediterranean climate are:

- a) **Thermo-hygrometer comfort in the summer and relative consumption**
- b) **Difficulty in calculating the performance of the passive systems in particular with regards to cooling**
- c) **The necessity to cover a portion of the winter thermal demands, even if reduced.**

The consolidated methodology which has been adopted by the architect to handle the problem of “Active/passive integrated retrofitting of school buildings” is structured in 3 iterative phases:

- **The analytical-evaluation phase, which lead to the identification of criticality and potentiality**
- **the target-planning phase, which lead to the definition of the intervention objectives/strategies**
- **the project phase, which lead to a detailed intervention project or to different flexible solutions based on differentiated investment programmes.**

At a general level the advantageous solutions for energy saving during the winter, can be listed as follows:

- **Insulation of the opaque envelope**
- **Replacement of frames**
- **Thermal solar systems for hot household water**
- **Geothermal heat pump systems**
- **Direct accumulation systems**
- **Transformation of internal courtyards into ‘buffer zones’**

Also, the advantageous solutions for energy saving during the summer, can be listed as follows:

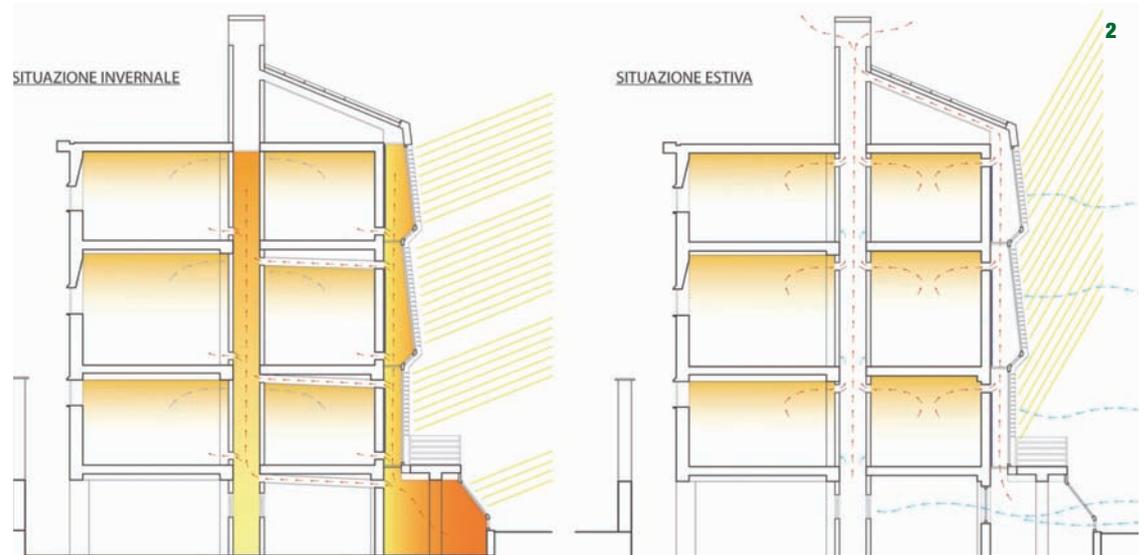
- **Permanent barriers**
- **Ventilated walls**
- **Ventilated roofs**
- **Green roofs**
- **Natural or ‘active’ ventilation systems**
- **Natural devices for the expulsion of hot air**
- **Increasing of the thermal mass**
- **Boost ventilation**



the professor ended his interesting speech with the hope of a commitment and an even more widespread experimentation between the different Mediterranean Countries, in order to develop common guidelines at a European level on 'Passive retrofitting' strategies.

1: Façade with a dimming system with reflective strips

2: Air circulation in summer and winter





The Programme is cofinanced by the European Regional Development Fund



Cyprus University of Technology

