ARCHITECTURE HERITAGE and DESIGN

Carmine Gambardella

XVI INTERNATIONAL FORUM

Le Vie dei Mercanti

WORLD HERITAGE and KNOWLEDGE

Representation | Restoration | Redesign | Resilience

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Collana fondata e diretta da Carmine Gambardella

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Le Vie dei Mercanti
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Le Vie dei Mercanti _ XVI International Forum

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Le Vie dei Mercanti
XVI International Forum

Napoli | Capri
14 - 15 - 16 June 2018

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Scholars has been invited to submit researches on theoretical and methodological aspects related to Smart Design, Planning and Technologies, and show realapplications and experiences carried out on this themes.Based on blind peer review, abstracts has been accepted,conditionally accepted, or rejected.Authors of accepted and conditionally accepted papershas been invited to submit full papers. These has beenagain peer-reviewed and selected for the oral session and publication, or only for the publication in the conference proceedings.

Conference report

300 abstracts and 650 authors from 36 countries:

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160 papers published after double blind review by the International Scientific Committee

Preface

In the present era, technologies are becoming increasingly important in helping and supporting man in research, knowledge and production activities, almost as if they were smart prostheses. With the theme of the XVI Forum "World Heritage and Knowledge", I propose to the International Scientific Community to debate and establish a comparison of knowledge carriers to communicate methodologies of good practices adopted and experiences in the use in the protection, conservation and safeguarding of cultural heritage and landscape as well as in the design of the "new, "that, adopting in the building processes and building construction Innovative Building Modelling, can realise a non-contemporaneity of what has the same date (Giulio Carlo Argan) respectful of the values of the pre-existing, legitimate because it participated ex ante and monitored becoming all its ethical, aesthetic and performance connotations.

With the Internet of things, for example, sensors that are used to produce data autonomously that widen the processes of knowledge on all levels, from the territory with its infrastructures, to the environment, to the artefacts entering into the body itself of their physicality, or, in the case of the new, building the project as a prediction throughout physical consistency.

Nevertheless, the use of new technologies allows for economies of scale, both temporal and economical, not only for the surveying and representation of the built and the territory in the analysis phase but above all for the management of the resulting data that makes the design activity of the restoration of the historical heritage and landscape or of the newly constructed in a single process no longer divided into steps but also unitary in concrete constructions and the realisation of the works, in the intermediate checks, in the testing, in the monitoring and in the programmed maintenance.

In conclusion, it is indispensable for the scientific community to highlight how technologies, without a responsible attitude that commit man's choices and knowledge in dealing with and planning appropriate responses to the issues and needs of the collective, can create a deception that unfortunately materialises with the subtle persuasion of uncontrolled astonishment that overwhelms the imagination.

Carmine Gambardella

President and Founder of the Forum

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Evaluation of the indoor comfort of the Arabic-Norman architecture for its valorization

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Abstract
In 2015, the Norman Arabic itinerary of Palermo became a World Heritage Site. Among the monuments of this itinerary, the Zisa palace is an extraordinary example of building typology presenting some unique technological and environmental characteristics because, originally, it was characterized by the integration of some conditioning passive systems for the improvement of the indoor comfort.
Zisa was built in 1160 by Arabian; it was characterized by the presence of an evaporative cooling system and natural ventilation that guaranteed levels of comfort that could be satisfactory even today.
The research proposes the results obtained through the application of a fluid dynamics software able to simulate the internal comfort conditions obtainable with the presence of some of the conditioning passive systems present in the Zisa.
Some specific computerized simulations have been carried out to prove the hypotheses concerning air movement and temperature control in the interior of the building.
A computer model has been created; it considers the architectural configuration of the building, its position and its orientation according to the proposals of different historians.
The work has achieved results that could enable some of these systems to be put back into operation.
The application of this results could represent an added value in the enhancement of the Zisa for the benefit of the entire UNESCO cultural route.

Keywords: Restoration; UNESCO; Indoor comfort; Passive Systems.

1. The World Heritage valorization

Every year UNESCO declares its world cultural heritage throughout the world. Finally in 2015, the Norman Arabic itinerary of Palermo became a World Heritage Site. Palermo, is a tourist destination of thousands of visitors from all over the world thanks to the presence of buildings of high historical and monumental value of the Norman Arab period and the Baroque period.
The Cathedrals of Cefalù and Monreale and their cloisters and the Palermo's monuments as the Palatina Chapel, the Royal Palace, the Zisa palace, the Cuba, the Ammiraglio bridge, together with the churches of San Giovanni degli Eremiti, Santa Maria dell'Ammiraglio and San Cataldo constitute a unique itinerary for cultural syncretism regardless of religious and political differences, an Arab-Norman and Byzantine heritage that has settled in history while maintaining its connotative characteristics. An extraordinary and evocative itinerary but also a major challenge for Palermo, which until now has not been able to enhance its potential and of which the Zisa palace represents an emblematic example enclosed between poor quality construction difficult to reach from a distracted tourist. The Zisa palace constitutes a wonderful example of Arab-Norman architecture that today, thanks to a substantial restoration, is rediscovering its position in the architectural panorama of the rich history of Palermo.
On March 2018 an event was organized for the valorisation of some monuments of the itinerary. Along the east side of the Zisa palace, films have been projected that allowed us to review how the original decorations of the building should have been.
But the importance of Zisa lies mainly in keeping the passive systems for the improvement of environmental comfort impact.
This building is an exceptional a "bio-climatic machine" accessible to everyone.

Fig. 1: The World Heritage itinerary in Palermo, with its representative monuments.

2. An important tile of The Norman Arabian itinerary in Palermo: the Zisa Palace

The Zisa palace, if seen in its historical context, is not a singular architectural phenomenon, but it is linked to the Fatimid architectural tradition that from the north of Africa, with the expansion of the Islamic culture, had crossed the whole Mediterranean area even before the Normans arrived in Sicily.
Technological and constructive solutions, aimed to obtain the best indoor climate comfort, are already found in all the Islamic architectural tradition that goes from the ninth to the twelfth century.
In Egypt, in Syria, as in the entire Maghreb area, we could find palaces and residences where the constructive wisdom - realizing those systems of natural air building conditioning - goes far beyond a simple and empirical experimentation.
The complex was a place dedicated to the sovereign's rest and solace. Even today, it looks like a massive parallelepiped with two protruding volumes on the short sides.
It was characterized by the presence of an evaporative cooling system and natural ventilation, that guaranteed levels of comfort that could be satisfactory even nowadays.
With its 36.40 meters of length, 19.60 meters of width and 25.70 meters of height, it spread itself over three levels with a longitudinal North-South orientation. This arrangement is not accidental because, being a royal summer residence, the most important rooms were oriented to the East, exposing them to the low and warm sun in the morning. The rooms arranged on the West side, receiving more solar radiations, are protected by insulating elements, such as the thick stony walls and the inner cavity space, consisting of corridors that make up a thermal mass of protection from excess summer heat. On this façade there are also only small windows, in order to prevent the heat to spread during the hottest days.
The building is articulated around a squared room that is really the pulsating heart of the complex: at the ground floor it is located the room of representation, the so called *Fountain room* with its stony *Salsabil*. This room - with its double height, the rich wall decorations and the presence of water - is a distinctive feature of Islamic architectures.
Among the various design features, the most important role is played by natural ventilation system inside, which, before the several changes which the building has been subjected to over the centuries, could ensure a constant flow of fresh air and the expulsion of the warm.
In addition, the upper terrace that originally opened in the middle allowed rainwater to fall into the *impluvium* of three open areas on the second floor and then be channelled into conduits cut into the ceilings of the floors. In front of the East façade there is a large tank for collecting water coming from the internal fountain called *Peschiera*. This large body of water as well as hosting colourful fish and lake plants, had the function, of a bio-climatic type, to further cool the sea breeze that passed through the *Genoardo* park around the building.

Fig. 2: Actual aspect and a painting of Zisa palace by Rocco Lentini (1935)

3. Passive system for energy efficiency

For the ancient Norman-Arabic builders, at those latitudes, the main problem to solve - wanting to offer to the royal court a pleasant place as well as a "climatic comfort" according to the artistic and naturalistic point of view - was to ldecrease the air temperature in order to make the hot heat of torrid Palermitan summers less suffocating. The Zisa architects and engineers thought more about obtaining summer cooling, rather than winter heating, using passive systems.
The passive systems have ancient origins: they were developed to mitigate the summer heat and the winter cold. They have been developed mainly in Mediterranean and Middle Eastern countries.
These kind of techniques for building air conditioning do not involve the use of artificial energy, but use physical-technical mechanisms, natural or induced, designed to ensure the thermal comfort without consumption of exogenous energy.
Empirically designed and developed, they have become popular in hot countries to mitigate the effect through natural expedients: these systems utilize different principles such as natural ventilation, evaporative, cooling, control of solar radiation, the building thermal mass and the heat exchange with the ground.
The first analogy that we notice compared to the current bio-architecture is the importance that the Zisa designers have given to the orientation of the building both with respect to the path of the sun and above all with respect to the incidence of winds.
A model has been created and georeferenced to Palermo’s latitude and longitude coordinates (Latitude 38.11°, Longitude 13.65°) and solar radiation values have been assigned in a summer day (26th August) in order to guarantee a certain amount of shaded areas and thermal gradient.

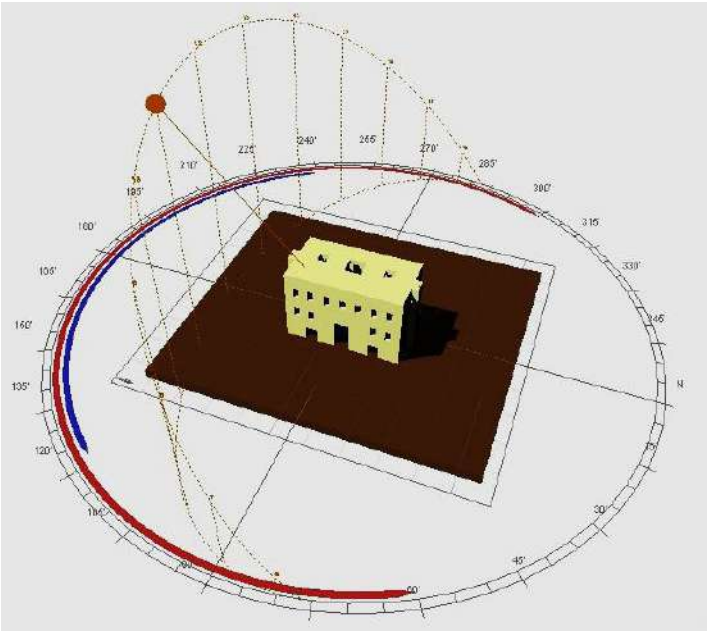

Fig. 3: Stereographic diagram of sun (on 26th August), developed by Autodesk Ecotect Analysis 2010.

Fig. 4: Big windows for the best captation of sea-wind from East side and smallest windows on West façade, in order to reduce the solar irradiation.

The study of the solar path through a simulation program made it possible to verify the behaviour of the building with respect to solar irradiation.
The result is that the East façade is equipped with openings capable to capture the cool breeze of the morning and the portico protect the most internal environments of the *Fountain room* On the other hand, the West-facing façade consists of a double wall with small windows. This constitutes a system of thermal mass capable to contrast the warmer afternoon solar radiation.
In particular, it has been used rubble-filled limestone wall (called "*a sacco masonry*") for the external walls (having a tickness of 3.2 meters at ground floor, 1.9 meters at first floor, 1.7 meters at the second floor, while the thickness of internal walls is about 2.2 meterst at ground floor, 1.4 meters at first floor, 1.2 meters at the second floor).

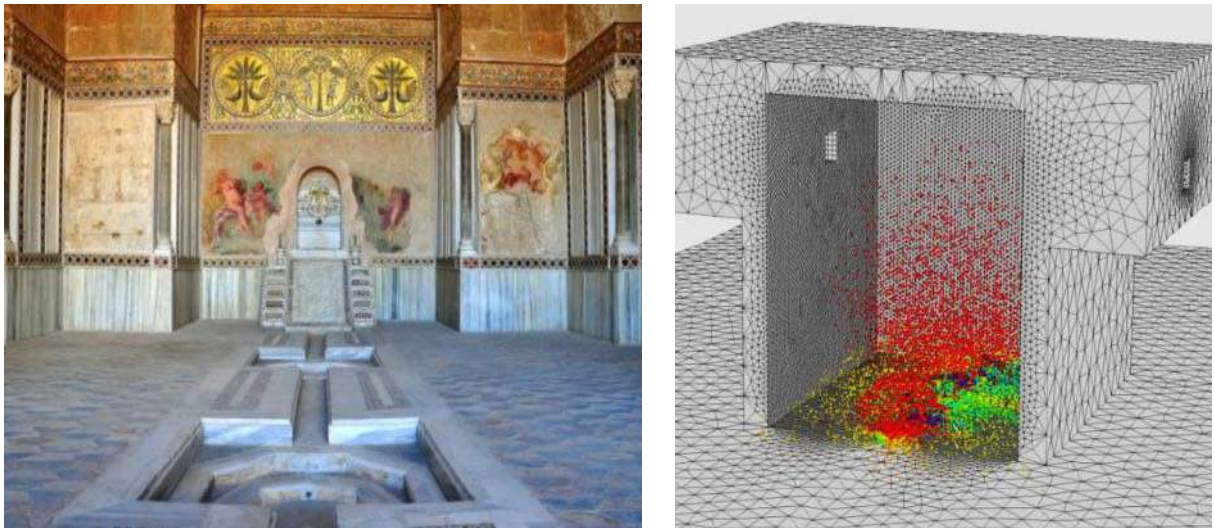

Fig. 5: Fountain room – the *Salsabil* – Simulation of the Water particles nebulization

We would also verify the working of natural passive cooling systems employed in the ancient building of the Zisa palace throughout CFD (Computational Fluid Dynamic) software application. Particularly we have define, through computational tools, a model to compare and to set proposals, able to actualize the original passive systems conceived and developed in an empirical way.
Nowadays the scientific knowledge and the modern technologies allow to understand the working of passive systems in order to apply them on buildings to improve indoor comfort.
This can be obtained through a new approach that involves the elaboration of design strategies based on the development of techniques and on computational and control tools.
The model created considers the building architectural configuration, its position and its orientation. The adopted architectural configuration is the most shared, proposed by Prof. Bellafiore.

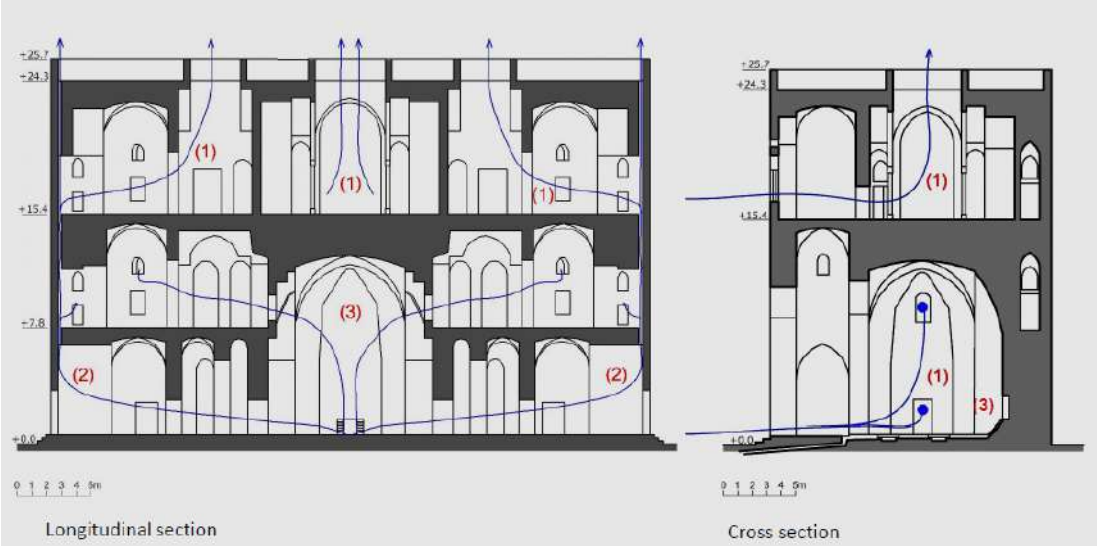

Fig. 6: Natural Ventilation hypothesis of prof. Giuseppe Bellafiore: (1) Upward movement favored by the pressure gradient,(2) Channels operation as a exhaust fans of fresh air, (3) Evaporative cooling due to the *Salsabil*.

4. Computational fluid dynamics (CFD)

Specific simulations were carried out using the Ansys Fluent CFD software to test the hypotheses concerning the movement of air and temperature control inside the Zisa.
The time interval analyzed is between 6 a.m. and 12 a.m. Moreover, between 12 a.m. and 3 p.m., it has been considered the wind action, in order to simulate the effects of sea breeze, which is generated in those hours. It comes from East and it is considered with low intensity (0.5 m/s) and an initial temperature of 25°C, in order to analyze the model under the most unfavorable conditions.
With regard to the building, the rubble-filled stone wall has been schematized by setting a material whose thermo-physical properties are the weighted mean between real materials values.
Particularly, density (1306kg/m3), specific heat (1362J/kgK) and thermal conductivity (0.64W/mK) have been considered. Air has been schematized according to Bousinnesq density model (1.225kg/m3), with a thermal expansion coefficient of 0.003 Salsabil main action consists of water particles nebulization due to the roughness of surface. It has been simulated by creating a surface injecting water particles with a diameter of 10-4mm, with a flow rate of 0.5kg/s and with a speed of 0.1m/s.

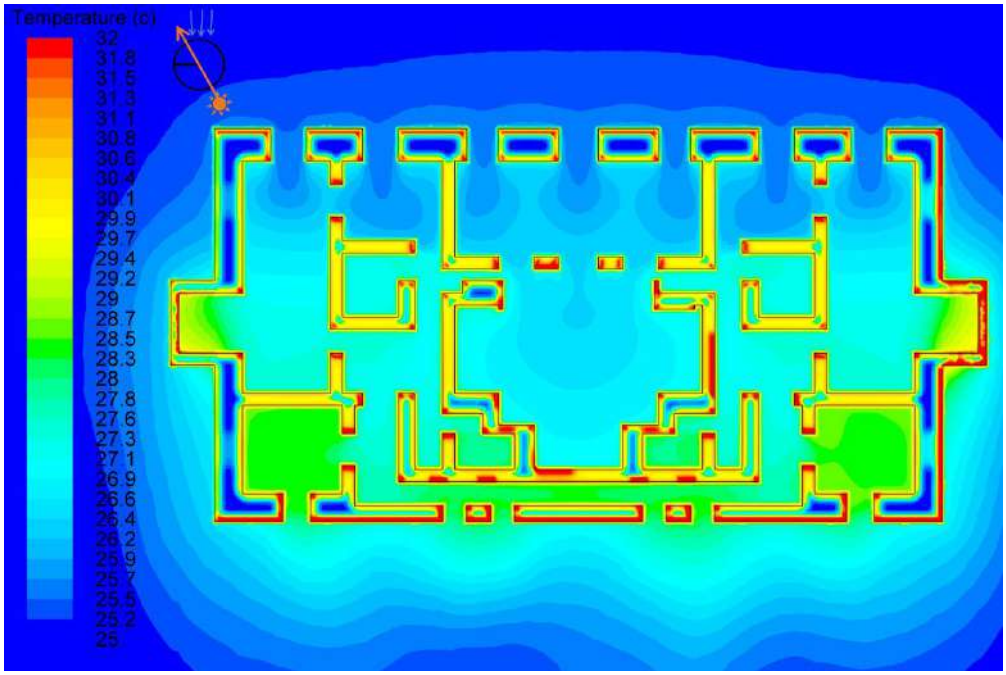

Fig. 7: 3 p.m., temperature on second floor

In the software the temporal development of the phenomenon is not-continuous, therefore the simulation considers "time steps" lasting three hours. Looking at the results obtained at 12 a.m. and at 3 p.m., it can be observed that solar radiation heat on exposed surfaces cannot entirely conduct itself through the wall, but affects only the outer portion. The wall dissipates heat, due to radiation, during the day and acts as an insulator, thanks to the constituent material features, but more importantly thanks to its high thick: only the thinnest walls (40cm) on the South side are completely traversed by heat, because they had already underwent solar irradiation over nine hours.
With regards to the effects of natural ventilation, in the daily hours with no wind (6-12 a.m.), it can be observed that a natural ventilation rises up in the rooms. It happens because of the thermal gradient which is established between external and internal environments. It is more evident in the rooms on the East front of the building, which undergoes only a soft radiance in the morning. It is shady during afternoon hottest hours and is cooled by the basin, the *"peschiera*".

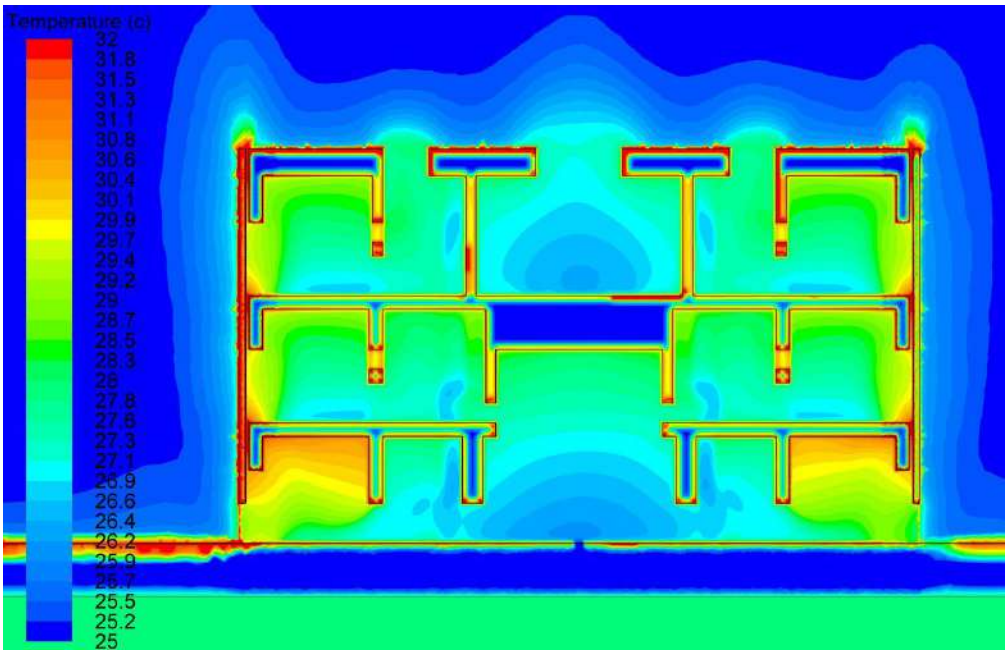

Fig. 8: 3 p.m., temperature on longitudinal section.

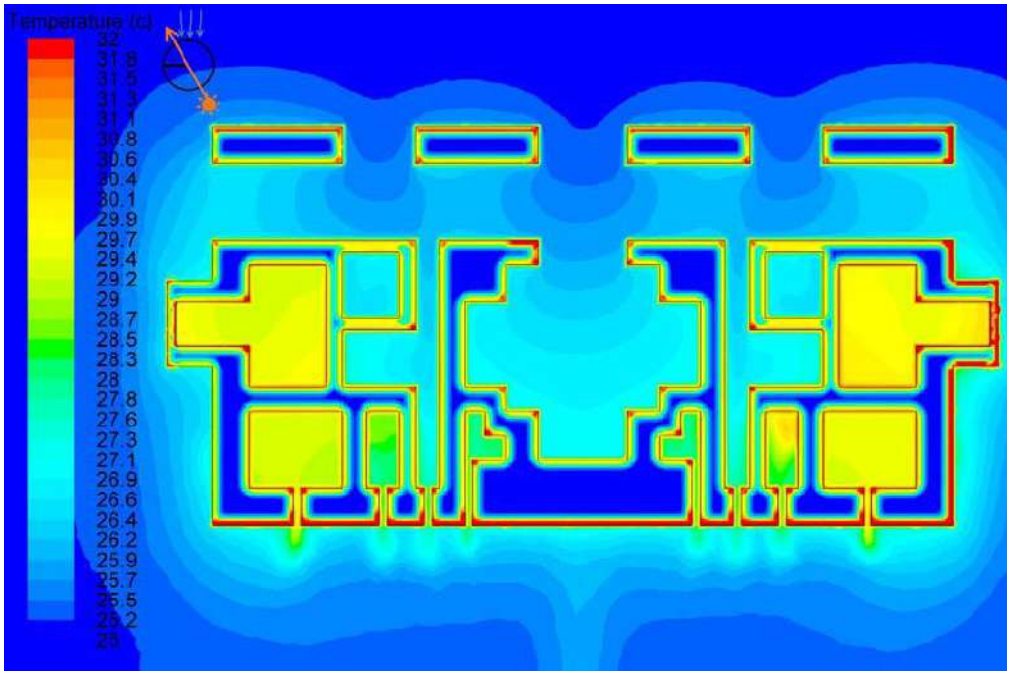

Fig. 9: 3 p.m., temperature on ground floor.

Chimney effect starts in the Fountain Room and in the central hall (probably the real "sollatia" of the sovereign); this entails that hot air is expelled from the top and the fresh air is drawn from outside through the openings (Fig.12-13). The particular shape of these rooms makes them fairly cool (28-29°C), but in the rooms placed in the two wings of the building, that are less ventilated, the hot air piles up and stratifies itself, reaching temperatures up to 30°C (Fig.13).
The building shape facilitates the use of the pressure gradient due to the breeze. Particularly, at 3 p.m., air flow rises into the building, following different paths from east to west. The air movement involves many different rooms until the maximum value of 1m/s. In this case the internal temperature does not exceed 30°C, because the breeze has an initial value of 25°C. The upwind rooms, thanks to the shape of the openings, are the most cooled, especially the lobby (the Fountain Room), at the ground floor, and the corresponding room above, where the highest temperature is 27°C. From the Fountain Room, which is in overpressure due to the wind effects, the air is transmitted to the adjacent areas on the ground floor and first floor at a maximum speed of 0.85m/s.
The western locals, are warmer, because the breeze comes in them with less intensity and after being heated. The analysis of the results obtained from simulations on the Zisa Complex shows the thermodynamic behaviour influenced by the room position and the wall stratigraphy finalized to indoor control, as it's possible to see in many old buildings.
It has been observed that most of the elements present in the Zisa complex respond to the functions assigned to them in literature, and some of the hypothesized phenomenon have been verified by the results (building orientation, activation of natural ventilation, the presence of thermal mass, etc.).
The assumptions that consider fundamental, for the purpose of thermal comfort, the air movement inside the building for thermal gradient or pressure gradient and the control of the solar radiation effects, have been substantiated by the obtained results.
In the more stately parts of the building, in fact, there are always good thermal conditions during the day, especially in the vestibule and in the central rooms.
For this reason the devices particularly effective are the arrangement of internal and external windows, the three openings in the original roof, the considerable thickness of the building envelope, the north-south orientation and the eastern large openings of the portico that allow to capture the sea breeze.

5. Conclusions

The aim of the research was to focus attention on the exceptional correspondence that is found between the Zisa air conditioning system and the technological solutions that a new way of doing architecture is experimenting in today's landscape of construction.
Currently, a project is underway to re-activate the evaporative cooling system of the salsabil fountain. This operation would make it possible to use the fountain room as it was originally used. Furthermore, with a closed-circuit duct system, the external fish tank could be reconstituted with the possibility of ideally reconnecting the path to the fountain system of the new garden.

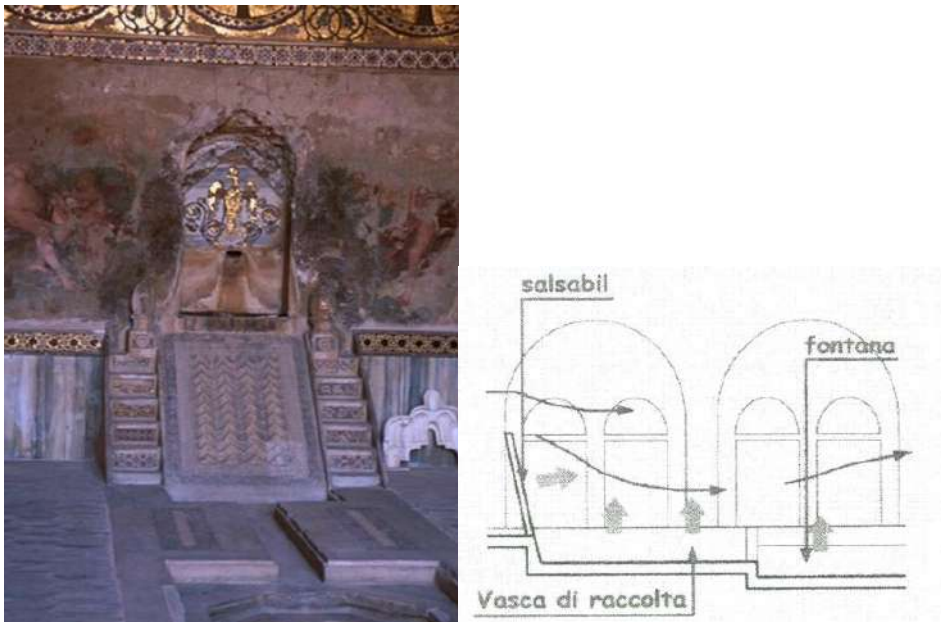

Fig. 10: Detail of the functioning system of the salsabil fountain.

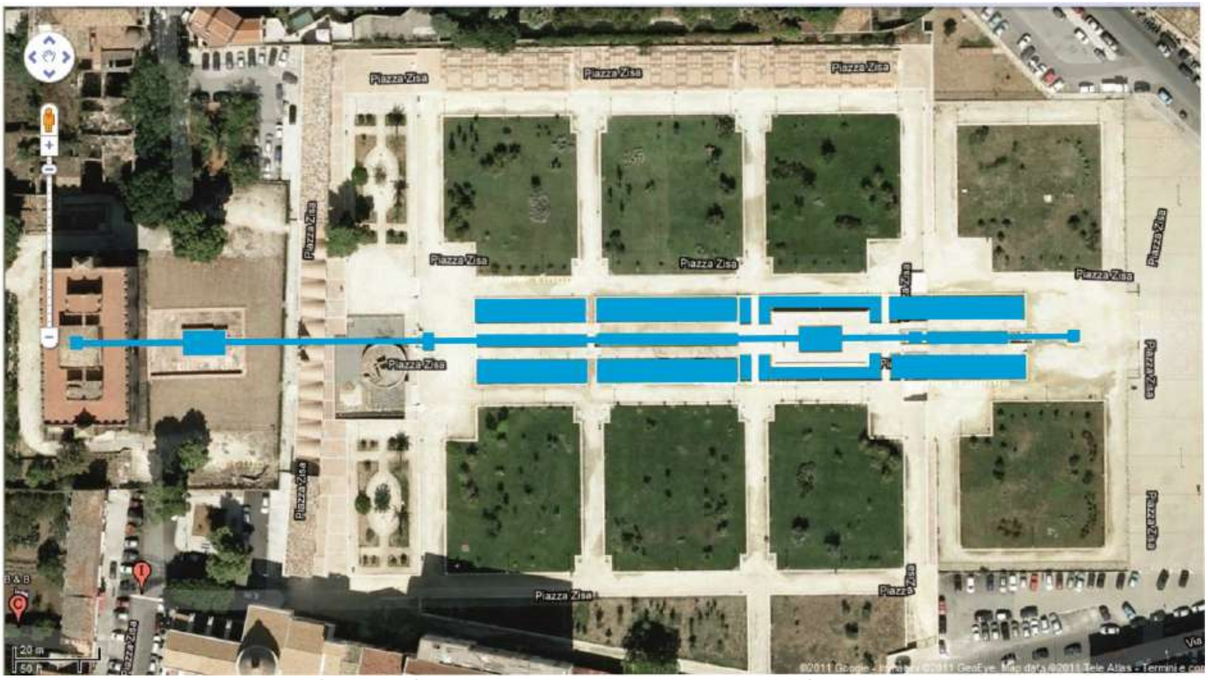

Fig. 11: The water route start from the fountain room end connects the new fountain park.

The rainwater drainage ducts could be completely rebuilt, putting the fountain system and the fish pond in front of it up again. This could represent an added value both from a tourist and a scientific point of view, as it would allow a campaign to be carried out on the real microclimatic conditions that have until now been only hypothesized. It would be important, even and especially for those who today experience the functioning of these systems, to give new life to this bio-climatic machine that remains a testimony of knowledge lost in the centuries and to which today we look with renewed enthusiasm. The best climatic comfort was obtained by combining together the intrinsic characteristics of some natural elements, such as air and water, with the forms of the architectural envelope. This is the great lesson of the past, this is the "sustainable" way of responding to the human needs of living. It is from this point that we must start again

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