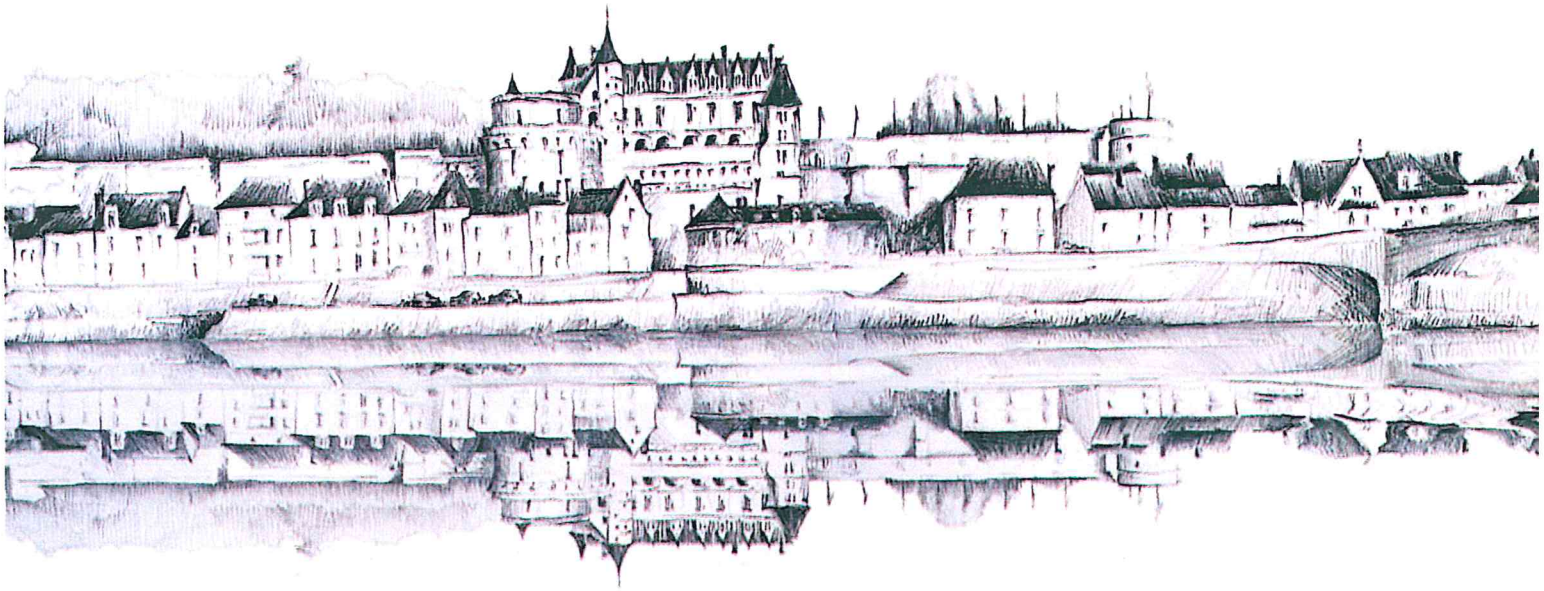

Water and Cultural Heritage

L'Eau et le Patrimoine Culturel

7TH INTERNATIONAL SYMPOSIUM ON THE CONSERVATION OF MONUMENTS IN THE MEDITERRANEAN BASIN

7ÈME SYMPOSIUM INTERNATIONAL SUR LA CONSERVATION DES MONUMENTS DANS LE BASSIN MÉDITERRANÉEN

PROGRAM

(SUBJECT TO MODIFICATION)

JUNE 6-9, 2007 – ORLÉANS, FRANCE

6-9 JUIN 2007 – ORLÉANS, FRANCE

UNESCO VAL DE LOIRE PATRIMOINE MONDIAL

UNIVERSITE D'ORLEANS

In June 2007, the 7th International Symposium on the Conservation of Monuments in the Mediterranean Basin takes place in Orléans, following previous symposia in Bari (1989), Geneva (1991), Venice (1994), Rhodes (1997), Sevilla (2000) and Lisbon (2004). This International Symposium is an opportunity for scientists, technicians and experts in the field of monument conservation and restoration to present their work and share ideas and experiences.

The theme chosen for the 2007 session, "Water and Cultural Heritage", is a reference to the classic problem of the interactions between water and building materials. It will also refer to problems associated with monuments in permanent contact with water, such as fountains, thermal baths, hammams and water pipes, as well as bridges, quays, mills and castles surrounded by moats.

This event is organized by the University of Orléans and the International Rivers and Heritage Institute (Mission Val de Loire – World Heritage), with the scientific certification of the International Group for the Monuments Conservation in the Mediterranean Basin. The International Rivers and Heritage Institute is supported by the Centre Region, the Pays de la Loire Region and the French Government. It aims to pull together the skills in managing heritage in river corridors that have been developed in the Val de Loire, and put these knowledge and know-how at the disposal of everyone at national and international level.

The symposium is supported by the Centre Region, the Conseil Général of Loiret, the City of Orléans, and the Direction of Cultural Affairs of the Centre Region.

PROGRAM

(subject to modifications)

Wednesday, 6 june / Museum of Orléans

09h00 **Opening of the reception desk** - Registration for the afternoon visits - Possibility to visit the Museum

14h30 **Official opening of the 7th Symposium**
Official speeches: Conseil régional du Centre, Conseil général du Loiret, Municipalité d'Orléans, Université d'Orléans, Mission Val de Loire

15h30 Break

15h45 **Scientific opening of the 7th Symposium**
Mr. Fulvio ZEZZA, Architecture Faculty, University of Venice, Italy; Mr. Michel RAUTUREAU, University of Orleans, France; Mr. Ary BRUAND, University of Orleans, France; Mr. Alain PLANÇON, University of Orleans, France; Mr. Vincent PERTHUISOT, International Rivers and Heritage Institute, Mission Val de Loire, France

16h45 **Guided visit of the city of Orleans** (the Loire quays, the old city, the cathedral, etc.)

19h30 **Cocktail offered by the City of Orleans** at the Hotel Groslot

Thursday, 7 june / Campus of the University of Orléans - Faculty of Law, Economy and Management

08h30 **Welcome** - Registration for the Saturday field trips

09h00 **Plenary session:** participants information and presentation of posters (3 minutes each)

09h30 **1st work session:** Each 20 minutes presentation will be followed by a 5 minutes debate

Amphi 1: General and technical studies (Chairman: Emilio Galan)	Amphi 2: Case-studies (Chairman: Luis Aires Barros)
Assessing the cleaning methods on the limestone façades in the Formerly Workers Hospital of Madrid, Spain / *Perez Monserrat E. M.; Varas M.J.; Fort R.; Alvarez de Buergo M.* **Damage from hygric swelling** / *Scherer G.W.; Wangler T. P.; Duffus P.*	**Two Sydney forts fighting the tide of decay** / *Faddy J.* **Chianalea di Scilla (reggio Calabria, Italia): a case-study of sea water between buildings** / *Barila G.* **The social club of the manzanera in Calpe, Alicante (Spain) (work of Ricardo Bofill). Study of the alteration of his materials** / *Cereceda L. M.; Spairani Berrio Y.; Garcia Del Cura M. A.; Prado Goeva R.; Huesca Tortosa J. A.*

10h45 **Break** - Free visit of the posters exhibition

11h15 **2nd work session:** Each 20 minutes presentation will be followed by a 5 minutes debate

Amphi 1: General and technical studies (Chairman: Emilio Galan)	Amphi 2: Case-studies (Chairman: Luis Aires Barros)
Controlling crystallization pressure by surface modification / *Scherer G.W.; Valenza J. J. II; McNall M. R.* **Investigating moisture/salt load damages of salt-resistant plasters: from laboratory specimens to practical test panels** / *Nasraoui M.; Mertz J.-D.* **Performance of selected materials containing different mixtures of salts after water repellent treatment** / *De Clercq H.*	**Rainwater drainage system investigation of an historical hammam by using non-destructive methods** / *Tavukcuoglu A.; Disli G.; Tosun L.; Grinzato E.; Caner-Saltık E. N.* **"Salus per aquam": architecture and technics make an healthy union with water in thermal and hydrotherapic baths, collective hygienical establishments, specialistic sanitary housebuildings** / *Campisi T.* **The Zaghouan-Carthage aqueducts and their nymphaea (Tunisia)** / *Ferchiou N.*

12h30 **Lunch at the University restaurant** - Free visit of the posters exhibition

14h30 **3rd work session:** Each 20 minutes presentation will be followed by a 5 minutes debate

Amphi 1: General and technical studies (Chairman: Ary Bruand)	Amphi 2: Case-studies (Chairman: Luis Aires Barros)
Improvements in the decayed microstructure of marble by treatments with nano dispersive solutions / *Caner-Saltik E. N.; Orial G.; Mertz J.-D.; Demirci S.; Hugon P.; Akoglu K.G.; Caner E.* **Pore network modification by salt crystallization of experimentally weathered sedimentary stones** / *Angeli M.; Benavente D.; Hébert R.; Bigas J.-P.; Menendez B.; David C.* **A novel application of mesoporous molecular sieves: consolidating stonework** / *Mosquera Diaz M. J.; De Los Santos D. M.* **Thermal recording during experimental weathering of limestones: the role of imbibition on salt crystallization and rock decay** / *Hebert R.; Angeli M.; Bigas J.-P.; Benavente D.*	**Sea salt dispersion in stream valleys and stone decay** / *Koui M.; Zezza F.; Cheilakou E.* **Restoration and technological and functional rehabilitation in a Veneto villa** / *Michieletto P.; MORELLI M.* **Characterization of a brick masonry by NDT analyses : the Terese convent case study, Venice** / *Zezza F.; Galgaro A.; Di Sipio E.; Di Pietro F.* **Saferguard and conservation of the fontain of the 99 spouts of L' Aquila: state of art within past, present and future** / *Quaresima R.; Volpe R.*

16h10 **Break** - Free visit of the posters exhibition

16h30 **4th work session:** Each 20 minutes presentation will be followed by a 5 minutes debate

Amphi 1: General and technical studies (Chairman: Ary Bruand)	Amphi 2: Biological aspects (Chairman: Michel Rautureau)
Laboratory thermographic analysis of masonry specimens. Capilarity and drying / *Cristian Magalhaes A.; Matias L.; Vilhena A.; Pina Santos C.; Do Rosario Veiga M.* **Evaluation of the durability of water-repellents applied on limestone, after 6-year of ageing in natural environment /** *Moreau C.; Verges-Belmin V.; Leroux L.; Fronteau G.; Barbin V.* **Segmentation of X-ray tomographic images: contribution to weathering analysis of building limestones originating from historical buildings /** *Le Trong E.; Rozenbaum O.; Rouet J-L.; Bruand A.*	**Influence of water on the microbial communities of Altamira cave (Cantabria, Spain) /** *Portillo M. C.; Gonzalez J. M.; Cuezva S.; Sanchez-Moral S.; Saiz-Jimenez C.* **Consequences of a high microbial diversity detected in caves containing paleolithic paintings /** *Gonzalez J. M.; Portillo M. C.; Saiz-Jimenez C.* **Microbial communities in painting-holding shelters in Aragon (Spain) /** *Gonzalez J. M.; Portillo M. C.; Alloza R.; Saiz-Jimenez C.*

17h45 End of the work session

19h00 **Cocktail offered by the University of Orléans**

Friday, 8 june / Campus of the University of Orléans - Faculty of Law, Economy and Management

08h30 **Welcome** - Registration for the Saturday field trips

09h00 **Plenary session:** participants information and presentation of posters (3 minutes each)

10h00 **5th work session:** Each 20 minutes presentation will be followed by a 5 minutes debate

Amphi 1: General and technical studies (*Chairman: Michèle Prats*)	Amphi 2: Case-studies (Chairman: Maria Koui)
Effect of protective surface treatments on the hydraulic properties of porous building stones / *Beck K.; Parant M.-A.; Bailli P.; Brunet-Imbault B.; Muller F.; Al-Mukhtar M.; Rouet J.-L.* **Suitability and evaluation of andalusian white marls as raw materials for a hydraulic lime production for building restoration /** *Galan E.; Markopoulos T.; Miras A.*	**The building complex of the Arsenal in Kaliagra, Mount Athos /** *Hadjiantoniou P.* **Aerial water conduits in the Roman Aqueduct of Carthage: crusts and mortars /** *Alvarez A.; Figueiredo M.-O.; Veiga J. P.; Silva T. P.; Pitarch A.*

10h50 **Break** - Free visit of the posters exhibition
Posting of the field trip groups

11h15 **6th work session :** Each 20 minutes presentation will be followed by a 5 minutes debate

Amphi 1: Heritage Management (Chairman: Michèle Prats)	Amphi 2: Case-studies (Chairman: Maria Koui)
Study of saving and conservation of Oserkon II tomb, Tannis, Egypt / *Helmi F. M.; Baranía A. A.; Mohamed R. A.* **Rainwater collection structures in the Karst region /** *Frangipane A.* **Volubilis archaeological site (Morocco): identification of building stones and determination of their provenance /** *Cadot-Leroux L.; Varti-Matarangas M.; Dessandier D.; Kamel S.*	**Thermal waters, salt damage and monument stone decay /** *Aires-Barros L.; Dionisio A.; Basto M.J.* **A survey on the deterioration processes of the Renaissance monument to Giovanni Calfurnio in the St. Anthony basilica in Padova /** *Fassina V.; Benchiarin S.; Baccelle Scudeler L.; Molin G.; Stefani C.* **Recovery of historic memory of the patrimony of the royal site of La Isabela and the Sacedon Baths /** *Trallero Sanz A. M.; Fernandez Tapia E. J.; Maza Vazquez F.; Sancho Oloriz A. P.; Nunez Perez D. J.; Ruiz Castillo J.; Cidoncha Maranon A.*

12h30 **Lunch at the University restaurant** - Free visit of the posters exhibition

14h30 **7th work session:** Each 20 minutes presentation will be followed by a 5 minutes debate

Amphi 1: Heritage Management (Chairman: Vincent Rotgé)	Amphi 2: Case-studies (Chairman: Anna Lobovikov-Katz)
Restoration of the inundation sluice of Hedikhuizen in the Netherlands / *Van Balen K.; Romeo C.; Hayen R.; Tak K.; Verhey B. J.; Swolfs M.* **Functional fitting of bridges and viaducts /** *Siviero E.* **Management of architectonical patrimony of catalan rivers in front of risk of flooding. The case of the Muga river basin (Catalonia, Spain) /** *Pavon Gamero D.; Ribas Palom A.; Serra Cervantes D.* **Tunisian southern inheritance: to restore correctly and develop durably, vector of local development /** *Abichou H.; Sghaier M.; Jouve A.-M.*	**The "Palombaro" ("Sassi" of material, Italy): the interaction between water and construction materials /** *Guida A.; Bixio A.; Conte A.; Mecca I.* **An interdisciplinary approach to assess water infiltration in monumental stone facades : the case of the Basilica of Collemaggio – L'Aquila (Italy) /** *Quaresima R.; Ambrosini D.; Paoltetti D.* **The preservation of a roman aqueduct in Arcadia from spring water /** *Koui M.; Yfantis D.; Cheilakou E.; Raftopoulou S.; Stratis E.; Zezza F.*

16h10 **Break** - Free visit of the posters exhibition

16h30 **8th work session:** Each 20 minutes presentation will be followed by a 5 minutes debate

Amphi 1: Heritage Management (Chairman: Vincent Rotgé)	Amphi 2: Case-studies (Chairman: Anna Lobovikov-Katz)
Conservation of cultural landscape along rivers through actions of risks mitigation / *Verdelli L.* **Problématique de la conservation d'un patrimoine fluvial, archéologique, ethnologique, architectural, dans son contexte naturel en Basse Loire angevine et armoricaine /** *Cayla P.* **Piercentre, an information system of the stone, quarries and monuments of the Centre Region (France) /** *Dessandier D.; Gateau C.; Lepretre J.-P.*	**Water and stability in the castle of Fontanellato /** *Coisson E.; Montrasio L.; Ottoni F.* **The roman amphitheatre of Durres: water form resource to problem /** *Coisson E.; Ghiretti A.* **Characteristics of bricks used in the domes of some ottoman bath buildings /** *Ugurlu E.; Boke H.*

17h45 **Plenary session: conclusions of the symposium and practical details concerning the field trips** *(Mr. F. Zezza)*

18h30 End of the work session

18h45 **Departure to the farewell dinner**

Saturday, 9 june / Field day

Itinerary n°1: Upstream from Orleans	Itinerary n°2: Downstream from Orleans
Visits of the Briare canal-bridge, the Château de Sully (currently under renovation), the roman basilica of Saint-Benoît-sur-Loire (to be confirmed)	Visit of the Château de Chambord and Château de Cheverny (to be confirmed)

POSTERS LIST

General and technical studies

Study of spontaneous water imbibition into limestones rocks / *Al-Mukhtar M.; Adib-Ramezani H.; Beck K.; Van T.T.*
Applying near infrared reflectance spectrocopy (NIRS) to cultural heritage / *Barrios Neira J.; Montealegre L.; Ortega A.; Merono J. E.; Aguilera M. J.*
The impact of thermal and hydric expansion on the decay of porous building stones / *Benavente D.; Cultrone G.; Rodriguez-Guerrero A.; Gomez-Heras M.*
Study of heat – and light – induced desorption of hydrated sulfates by powder X-ray thermodiffraction / *Cardell-Fernandez C.; Sanchez-Navas A.; Martin-Ramos J. D.*
Water and soluble salts on porous material: an experimental study of damages on bricks / *Colombo C.; Conti C.; Costanzi F.; Montonatos S.; Negrotti R.; Poli T.; Realini M.; Valentini M.*
Estimation of water permeability of building brecciated dolostones / *Cueto N.; Benavente D.; Garcia Del Cura M. A.*
Pore structure, fluid transport and natural stone decay: an experimental approach / *Figueiredo C. A. M.; Folha R.; Dionisio A.; Mauricio A.; Alves C.; Aires-Barros L.*
An integrated methodology for the moisture performance assesment of historic buildings / *Karoglou M.; Moropoulou A.; Bakolas A.; Krokida M. K.; Maroulis Z. B.; Konstantopoulos D. K.; Maroulis V. Z.*
Origin of yellowing on white marbles: natural and anthropogenic factors / *Pozo Rodriguez M.; Carretero M. I.*
Contribution of 3-D X-ray microtomographic image for the characterisation of weathered and unweathered building limestones / *Rozenbaum O.; Le Trong E.; Rouet J.-L.; Bruand A.*

Case-studies

Chianalea di Scilla (Reggio Calabria, Italia): a case-study of sea water between buildings / *Barila G.*
Stones of monuments in biocalcarenites and travertines: morphology and type of deterioration / *Barrios Neira J.; Montealegre L.; Sebastian E.; Cultrone G.; Beck K.; Al-Mukhtar M.; Alcover J.-F.*
Definition of microclimatic parameters based on water transfer and porous media properties to conserve prehistoric constructions : Cueva Pintada at Galdar, Gran Canaria, Spain / *Benavente D.; Canaveras J. C.; Sanchez-Moral S.*
Weathering processes affecting rock paintings in Villar del Humo Archaeological Park (Cuenca, central Spain) / *Benavente D.; Canaveras J. C.; Sanchez-Moral S.; Diez-Herrero A.; Gutierrez-Perezil.; Alonso-Azcarate J.; Lario J.*
Weathering processes in the court of "El Salvador" Church of Baeza (Province of Jaén, Andalusia, Spain) / *Campos Sunol M. J.; De La Torre M. J.*
The restoration of the roman bridge of Cordoba (Spain): a petrophysical investigation / *Cultrone G.; Sebastian E.; Luque A.; Urosevic M.*
Water management at Durocortorum (Rheims, France), diversity of archaeological structures and promotion of an undervalued cultural heritage / *Fronteau G.; Moreau C.; Chopin E.; Berthelot F.; Ardhuin M.; Balmelle A.; Rabaste Y.; Rollet P.*
Different types of deterioration of the Royal Summerhouse in the Royal Garden of Prague Castle / *Kopecka I.; Kolisko J.; Novotny J.*
Stone decay in civil heritage constructions due to salt crystallisation: salinetes bridge (SE Spain) / **MARTINEZ MARTINEZ J.;** *Barnabeu A.; Benavente D.; Del Cura G.*
Effectiveness of silica polymer-colloid for consolidating sedimentary stone / *Mosquera Diaz M. J.; De Los Santos D. M.; Mosquera M. J.*
The conservation state of Hafsid masonries from medieval reconstruction works at the Roman Aqueduct of Carthage, Tunisia / *Pereira Da Silva T.; Figueiredo M.-O.; Veiga J. P.*
The sinter of the ssocia Pretoria in Palermo / *Rizzo G.; Ercoli L.; D'Agostino F.*
The Idol's Fountain (Braga, NW Portugal). A water/rock monument / *Sequeira Braga M. A.; Alves C.; Silva P.; Lemos F. S.; Lima A.; Pamplona P.; Aires-Barros L.*
Influence of indoor environmental conditions on building materials of Algete Church (Madrid, Spain) / *Taborda Duarte M.; Varas M. J.; Fort R.*
Assessing the deterioration of frescoes using geochemical and geological data: two examples from Egypt / *Voudouris K.; Moussa A.; Stratis J.; Ali M.; Christaras B*

Biological aspects

Physical and mineralogical analysis of bioremediated limestones / *Anne S.; Rozenbaum O.; Rouet J.-L.; Plançon A.*
Microbial Communities involved in the deterioration of Santa Clara-a-Velha Monastery (Coimbra, Portugal) / *Miller A. Z.; Laiz L.; Dionisio A.; Macedo M. F.; Saiz-Jimenez C.*
Biological mortars – an original concept for heritage conservation / *Orial G.; Bousta F.; Vieweger T.; Loubiere J.-F.*
On the presence of acidobacteria in the cave of Dona Trinidad (Malaga, Spain) / *Stomeo F.; Gonzales J. M.; Saiz-Jimenez C.*

Heritage Management and Enhancement

Exhibition of paintings and free-hand drawing / *LoboVikov-Katz A.*
Karst soil and rising damp in Sassari: guide lines for restoration of Canopoleno complex / *Rosina E.; Gizzi S.; Scudino D.; Della Torre S.; Valentini M.*

KARST SOIL AND RISING DAMP IN SASSARI: GUIDE LINES FOR RESTORATION OF CANOPOLENO COMPLEX

Stefano Gizzi (1), Daniela Scudino (1), Stefano Della Torre (2), Elisabetta Rosina (2), Massimo Valentini (3)

(1) Soprintendenza ai Beni Architettonici ed il Paesaggio delle Province di Sassari e Nuoro (IT); (2) Politecnico di Milano (IT), Dipartimento BEST; (3) Politecnico di Milano (IT), Dipartimento di Energetica

Introduction

Collaboration between *Soprintendenza per i Beni Architettonici ed il Paesaggio delle Province di Sassari e Nuoro* and *BEST Dept.-Polytechnic of Milano* has focused on critical and historical research and investigation on the prominent architecture of "Canopoleno" complex.

Building of Canopoleno began between 16th and early 17th century; firstly it was "Jesuit *Casa Professa*" (ended in 1611), and later became one of the four original sites of the Order; at last, it was reused as new site of University (*Colegio Nuevo*). Between 18th and 19th centuries major modification occurred, above all inside the building, due to the change of uses (seminar, college, high school).

Original features are perfectly recognizable nowadays. Archive documentation shows that from the start, rising damp was a recurrent issue, due to bad quality of local stone (called "*pietra spugna*", sponge stone) and local geological morphology (karst soil). The claim found in archive documentation regards Canopoleno complex and generally, the whole historic center fabric. Rising damp remains main problem, up to now, although *Ministero per i Beni e le Attività Culturali* has directly managed complete restoration, which started in 1999.

Paper hosts results of studies and investigation performed by Polytechnic of Milano in the last three years, in order to find out the causes of damage and solutions for best re-using this important piece of historic urban fabric.

Historical overview

As structural in Sassari's urban fabric of historic center, Canopoleno is a significant part of Jesuit counter-reformation architecture, which had a "delayed" diffusion in Sardinia (fig. 1). From their arrival in Sassari, Jesuits inhabited an old building owned by Montanyans family.

Between the end of 16th and beginning of 17th century, Jesuits built Colegio Nuevo (nowadays it is University site), in front of Montanyans's building. In the area of the ancient Montanyans's house, between 1580 and 1607 they built the Church of Jesus and St. Mary's, and later their *Casa Professa* (mansion for priest and pilgrims).

Casa Professa was ended in 1611. Probably, some Jesuit architects contributed to buildings: G.Tristano, D. Verdina and especially G. De Rosis among them, contributed to definitive project. At that time, Jesuit professionals took the habit to travel between Spain and Italy to build most important Order sites up.

Canapoleno complex was set next to medieval Montanyans's house. From the beginning it showed damages due to rising damp, bad quality of local stone (called "*pietra spugna*", sponge stone) and karst soil.

Refurbishments occurred in 17-18th Centuries regarded an enlargement, the addition of a new floor, and subdivision of interior. Further modifications were caused by separating College (at second floor) from high school (at first and ground floor).

Leaving aside modifications, nowadays we can clearly distinguish original plant: a "C"-shaped plant, in which vaulted halls are set along a central aisle, and an elegant facade.

Figure 1 - Canopoleno complex in Sassari, 2005

In 20th century neglect caused major damage: roof collapsed, window frames were torn away, rising damp increased. Damage got worse until *Ministero per i Beni e le Attività Culturali* directly took management of the building in 1998, and in 1999 restoration began, to devote building to city picture gallery.
Restoration of last decade did not completely solve moisture issue (even thought an electro-physic system was installed), because of the presence of many holes, pits, springs and ponds underground.

Methods

Authors used visual analysis of materials, assessment of damage in the building and in most of nearby ones, historic chronology of major modification occurred in time to assume damage's causes, which resulted: rising damp, localized infiltration from sewerage and hydric system, spread rain waters, high Relative Humidity, different hygroscopical properties of the coating materials. Research aims to evaluation of the impact of episodic rising damp on historic buildings, due to scattered infiltrations and karst soil. Monitoring water content in stone masonry and its distribution allowed to evaluate ways of water coming in masonry and water content, treatment for drying moisture, and, at last, design guidelines for restoration and re-use of the building (despite of the unelimenable presence of water).
Measurement were taken during three beatings, on April and October 2005 and October 2006.
Diagnostics focused on:
1) A preliminary inspection by IR Thermography (IRT), that allowed to map colder areas of most damaged surfaces (ground floor and cellar, interior and exterior) [1].
2) Within these zones, samples were collected to measure water content, at different heights (along vertical rows) and distances from the masonry's surface (according to UNI 11085 "Beni culturali. Materiali lapidei naturali ed artificiali. Determinazione del contenuto di acqua: Metodo ponderale").
Moreover, a new method of monitoring was applied: *Fixed Points Method* (PPM) [2].

Fixed Points Method

Gravimetric test performed in Canopoleno, has been precise and reliable, nevertheless method keeps some contras:

- requires samples (few grams) of the materials under investigation, therefore it is minimally invasive;
- destructivity increases at any repetition of test, because new samples are required for each measurement;

- repetitions of sampling could collect different materials, because of high non homogeneity of masonry materials. In the case of Canopoleno, variability of materials is very high, although samples were collected in small and very close areas. Above all, samples coming from the inner layer of masonry were collected without visual inspection supplying the choice of quoin; most of samples have different porosimetric characteristics, and consequently their water absorption is different although water source is equal. Masonry's non homogeneity risks to invalid repetitivness of test and comparison of results obtained in the same place at different time.

To overcome listed contras, PPM has been developed.
First step of monitoring consists in operators drilling masonry to set brick cylinders in it (fig. 2). These small cylinders (4 cm long, 0.8 cm wide) have steady full tested properties (porosity, components, etc). They reach thermo-hygrometrical balance with masonry, by sealing masonry's holes. Cylinders absorb water proportionally to water content of masonry. Operators monitor water content by removing wet cylinders, weighting them and substituting them with dry ones. Since measures are taken from the same hole in time, they are not affected by non homogeneity of materials, therefore monitoring time can be extended without any destructive collection of new samples.

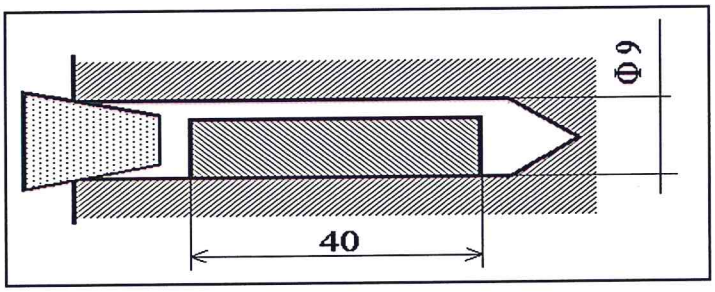

Figure 2 – Sketch and dimensions of brick small cylinder and its location inside masonry hole

Because of different water absorption of masonry and brick cylinders, water content of brick is proportional to water content of masonry; therefore results of PPM give only a qualitative indication of moisture content in masonry. In Canopoleno study case, high variability of materials increases difficulty of comparison between water content in masonry and in brick cylinders [3].
That is why operators chose only some points for PPM measurements, instead of repeating measures on the whole complex; results of thermo-hygrometrical tests performed in 2005, gave the location of samples containing higher percentage of water, and PPM was applied only in those areas.
During first measurements on April 2005, operators drilled masonry to collect gravimetric tests samples. On October 2005, brick cylinders were located in the holes previously drilled in masonry.
Substitutions of cylinder were performed on February, May and October 2006
Substitution consisted on:

- extraction of wet cylinders from masonry;
- putting them into glass test-tubes;
- sealing tube-test;
- relocation of new cylinder;
- sealing the holes with plasticine;
- transportation of the tube test onto laboratory;
- weighting (PU);

- drying them at 105°C until steady bulk reaching constant weight;
- weighting dried ones (PS).

Cylinders water content was obtained by

$$\text{Water content [\%]} = \frac{PU - PS}{PS} \times 100$$

3) Five RH/T probes have been performing microclimatic monitoring, one hour of recording rate: probes are set at ground floor, in Canopoleno cellar, and in Palazzo Ducale cellar (Palazzo Ducale is the city hall, built in 18th century, opposite to Canopoleno entrance). Measures performed in Palazzo Ducale, after restoration, are reference for Canopoleno.

Results

1) To verify rising damp hypothesis, authors firstly observed damage distribution and later used IRT to map colder areas. Investigation was performed at ground floor (inside and outside the building) and in the cellar. In colder areas, operators collected few samples of stones and plaster at different heights from the floor, according to steady procedures [3]. The surface temperature map allowed to correlate colder areas and evaporation flux, due to presence of water. Gravimetric tests allow to measure water content in samples.

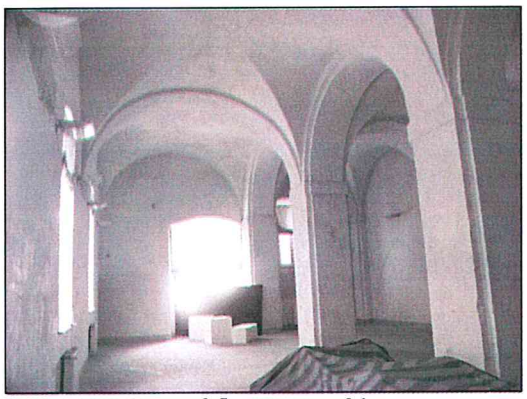

Figure 3 - Ground floor, room 21

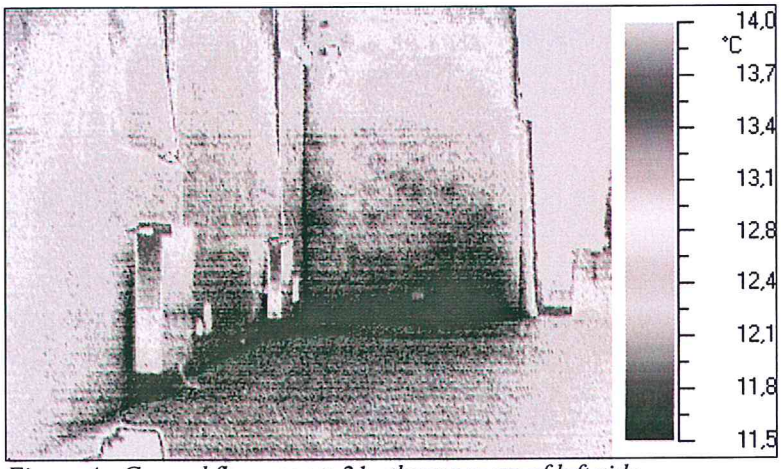

Figure 4 - Ground floor, room 21, thermogram of left side

Figure 4 shows IRT application for moisture detection in room 21's left side. Thermal gradient is around 1°C between floor and 1.2 m high. Gravimetric tests have been performed on this side too. Results are: average water content of a tufo sample is 4.8% (20 cm up to the floor in the black area). At a upper level, 60 cm from the floor, water content is lower 3.8.

Repetitions of test in spring and next fall had same results. Therefore, thermal gradient and water content distribution indicate the presence of a infiltration at the basis of left wall.
Authors drew a map to correlate and localize results of gravimetric tests performed in 2005 and 2006. Different colors represent average variation of water content between beatings: at least an increasing value among the row, light grey; decreasing value of average water content in the row, grey; no variation, black.

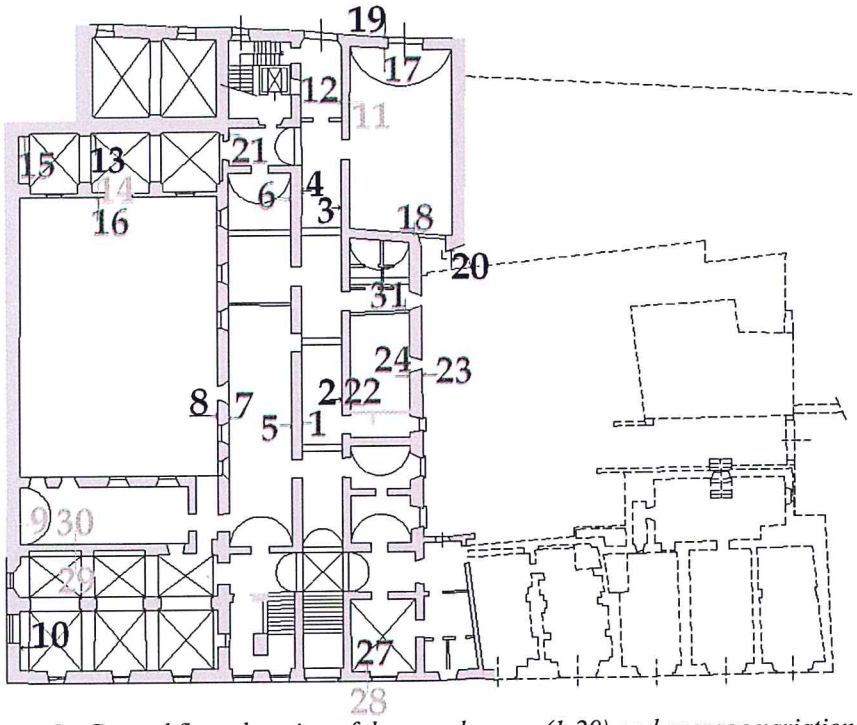

Figure 5 - Ground floor, location of the samples row (1-29) and average variation of water content in 2005-2006 measurements

Many rows (13) are grey, because most of them are due to highly humid samples placed at the basis of masonry. Nevertheless, many samples have an increase of water content (6 alignment). In other 6 alignments operators measured no changes. Collected data show a very discontinuous trend, due to random location of different stones in masonry, and irregular distribution of infiltration.
Non homogeneity of masonry affected results, especially those samples collected inside the structure. In fact, it was possible to collect the same material on the surface, because of visual analysis, but it was not possible to choose materials at 15-20 cm inside the stone.
Therefore, authors calculated average values between surface and deep samples, for each point of measurement, and qualitatively considered average values.
Authors achieved a quantitative evaluation by comparing data and graphics of each beating, point by point.
Following graphics show in details variation of average water content of surface and samples collected at 15-20 cm inside.

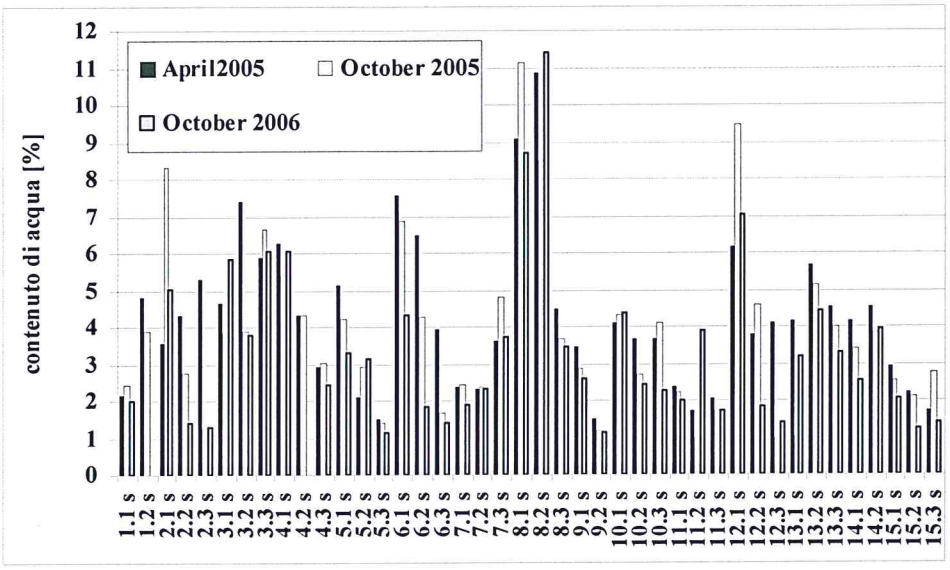

Figure 6 - Water content of samples 1.1/ 15.3. Samples are numbered with two figures: first means row, and second means height (around 20 cm, 60 and 80 from the floor)

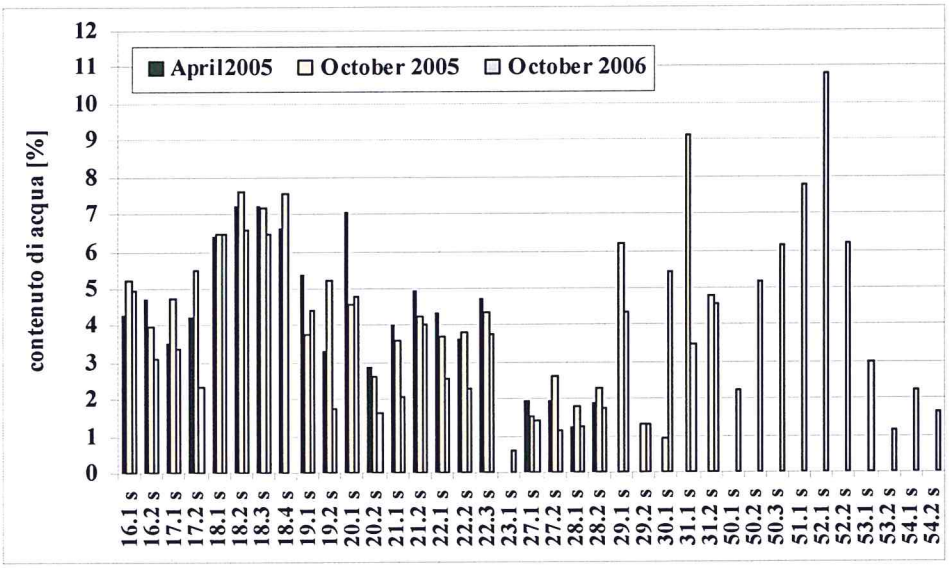

Figure 7 - Water content of samples 16.1/ 54.2. Samples are numbered with two figures: first means row, and second means height (around 20 cm, 60 and 80 from the floor)

October 2006 measurements have lower values of average water content, especially at the basis of masonry, but it is anyway high.
Moreover, in many samples water content increased. These samples are:
3.1, 8.2, 4.1, 7.1, 9.1, 18.2, 19.1, 20.1, 8.2, 11.2, 13.2, 2.3.
Resulted discontinuous trend of water content variation is due to non homogeneity of materials, variability of their absorption capability, and irregular distribution of infiltration.
Moreover, resulted values are very high, above all in samples
2.1, 8.1, 12.1, 16.1, 18.1, 50.1, 51.1, 8.2, 18.2, 52.2, 4.3, 18.3, 50.3.
The increase of water content is caused by rising damp, which is localized in many areas of plant. In addition, localized smaller infiltrations cause increase of water content in room 13, and rooms aligned along Via Santa Caterina, at cellar floor.

2) Operators installed four probes to monitor thermo.hygrometrical variation of microclimate in cellar and ground floor (rate of registration is one/hour). Moreover, a fifth probe has been placed in Palazzo Ducale cellar. The historic building is set in front of Canopoleno; it has similar building techniques, and same materials. Rising damp was one of major cause of its damage. It already went under restoration and professionals restored plaster of cellar and ground floor by white washing. Moreover they ensures a continuos ventilation in the cellar, in order to decrease RH. Therefore, Palazzo Ducale's microclimate monitoring constituted a study case for intervention and gave reference values for ambient condition.

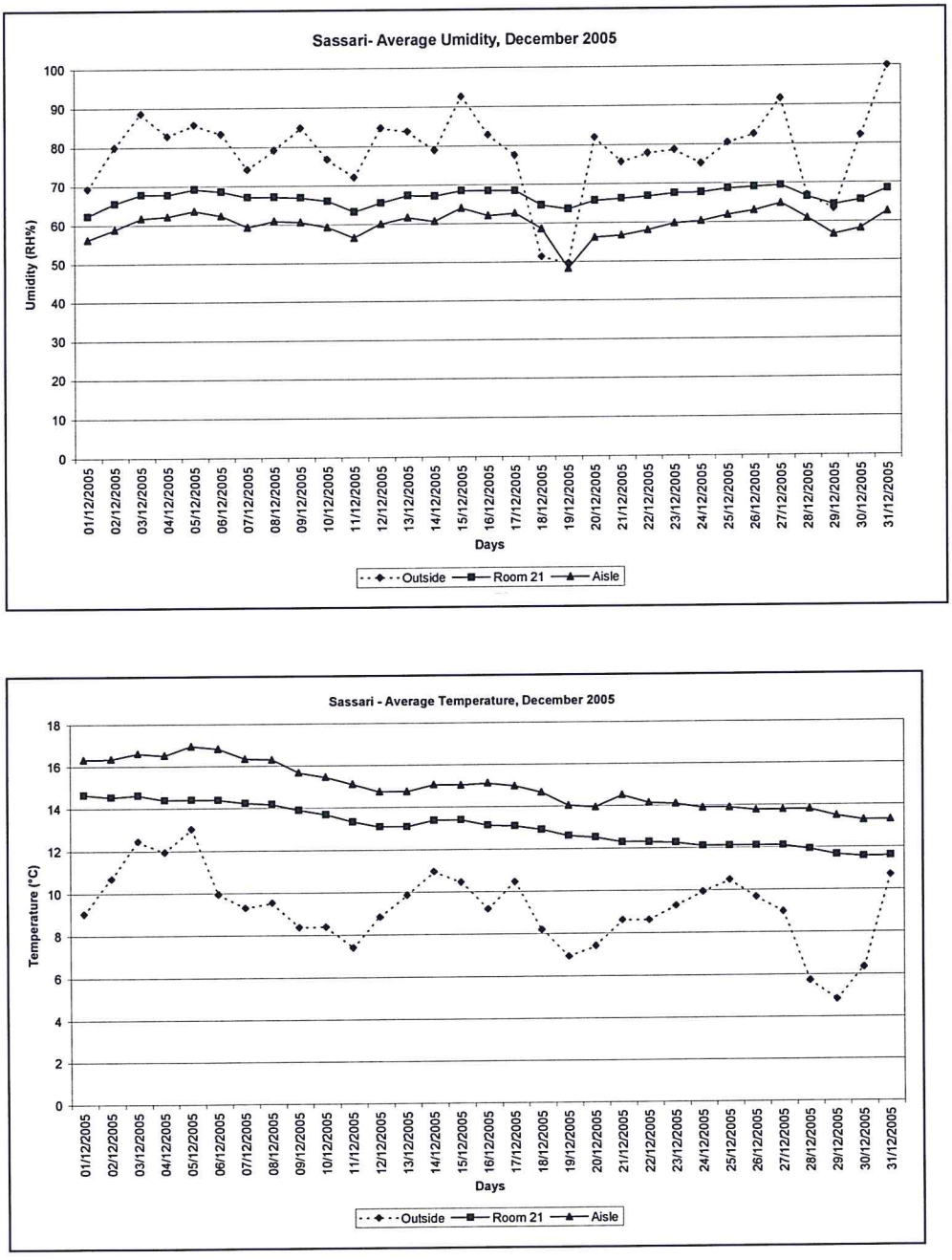

Figure 8 - Graphics of average daily values of T°C and RH on December 2005

Discussion

Results lead to the following points:

- Masonry components are different kinds of *calcarenite* stone: their water absorption function are highly differentiated
- Each kind of *calcarenite* stones, has a different evaporation time of water content, even at the same ambient conditions
- Water content is not steady but values are always high
- Moist masonry is within 60 cm up from the floor, only in few points moisture has higher distribution (due to the addition of localized minor infiltrations)
- Rising damp affects many walls; lower water contents are only in limited masonry. Seldom some part of structures resulted dry, but the building has episodic infiltration all over.

From these points comes that major cause of rising damp mainly depends on soil geology, without any possibility to intercept infiltration or collect water. Moreover, so differenced stones characteristics of absorption advise against any effective chemical barrier.

At last, even the experimental of electro-physic method for water's way out from structures, did not have satisfactory results. Humidity causes stones damage (surface pulverization, without large lacks or delamination of stones) because of presence of salts in *calcarenite* (nitrates and sulfates resulted from ionic chromatography). The last measurements by IRT and gravimetric tests allowed to pinpoint the positive effects of coating removal: thermal images showed a reduced extension of the areas where major evaporation flux occurs. Test results indicate that continuous evaporation will completely damage plaster, and in the meantime, presence of coating slows down drying process in masonry.

Indications coming from analysis results are that alternative solutions to the present plaster are white-washing or macroporous plaster. Both of them require programs of frequent maintenance. Contra is that continuous evaporation on surface will increases RH, which resulted already high at any time. An alternative solution can be suggested for a better re-use of rooms: ventilated counter-walls could supply undamaged surfaces for exhibition, and in the meantime they can decrease evaporation on stone surface.

Conclusions

Presented method for rising damp diagnostic resulted helpful to assess and detect decay's causes. Karst soil vanify most of intervention meant to prevent rising damp, such as chemical barrier, electrophysical methods and perimetral deadspaces. In fact chemical barrier application could have high contras in such a case. Differences of absorption could prevent a homogeneous spreading of products inside masonry. On the other side, the application of electrophysical method did not great results until now. Design of building use has to take into account thermal-hygrometrical characteristics of masonry, in order to find out best use compatible with authors's suggestion for facing rising damp damage.

Specifically a further microclimatic monitoring will be very useful to control ambient condition both during restoration yard and visitors attendance.

[1] E. Rosina, N. Ludwig, L. Rosi, *Optimal Conditions to Detect Moisture in Ancient Buildings. Study Cases from Northern Italy*, Thermosense XX, Orlando (USA) 1998, SPIE proceedings vol 3361, ISSN 0277786x, ISBN 0-8194-2810-8, ed. SPIE WA(USA), pp. 188-199

N. Ludwig, E. Rosina, *Active and Passive thermography to detect moisture in building materials*, Proceedings of 5th AITA, International Workshop on "Advanced Infrared Technology and Applications", CNR ed. Venezia 1999, pp. 166-175

[2] Valentini M., *Prime verifiche su murature in laterizio di una metodologia poco invasiva per la determinazione del contenuto di acqua*, Convegno nazionale "Architetture e manufatti del cotto. Approfondimenti di storia e cultura materiale, Palazzo dei Diamanti, Ferrara, 14-15 novembre 2005
Valentini M., *Una metodologia poco invasiva per la misura del contenuto di acqua delle murature*, Workshop "Monitoraggio e conservazione programmata", Venaria Reale, Torino, 25 novembre 2005, Kermes quaderni-Nardini editore, pp. 168-173

[3] E. Rosina, N. Ludwig, *Optimal thermographic procedures for moisture analysis in buildings materials,* Diagnostic Imaging Technologies and Industrial Applications 1999, Munich, Germania, SPIE procedings vol. 3827, ISSN 0277-786x, ISBN 0-8194-3313-6, SPIE ed. WA (USA)