MOdihMA

MOisture detection in historic MAsonry

Methods to prevent and reduce dampness in masonry

POLITECNICO
MILANO 1863

Consiglio Nazionale
delle Ricerche

UNIVERSITÀ
DEGLI STUDI
DI MILANO

When and how to reduce moisture content for the conservation of historic building.

A problem solving view or monitoring approach?

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POLITECNICO
MILANO 1863

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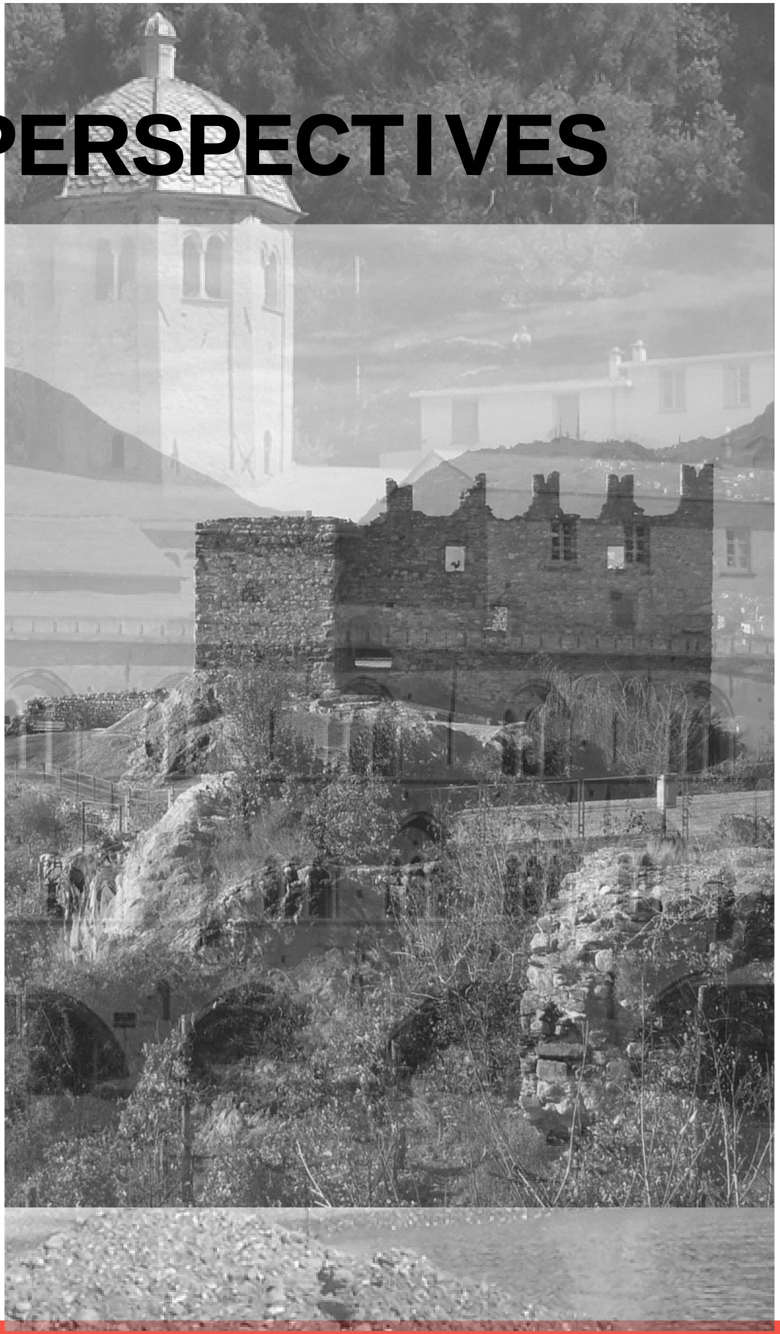
1. CONTEXT AND PERSPECTIVES



The aim of the Italian Code of the protection of Cultural Heritage leads to innovate the research of testing and studying the Cultural Heritage.

It defines Conservation as a planned and long-lasting process, overtaking previous concept of “restoration”.

Limited cost and invasivity of tests:

1) application on the widespread built environment

2) support all the planned conservation activities and strategy for obtaining the required knowledge and continuous assessment and cares

INVESTIGATION AND MONITORING

- Many steady and innovative diagnostics as seen in the day

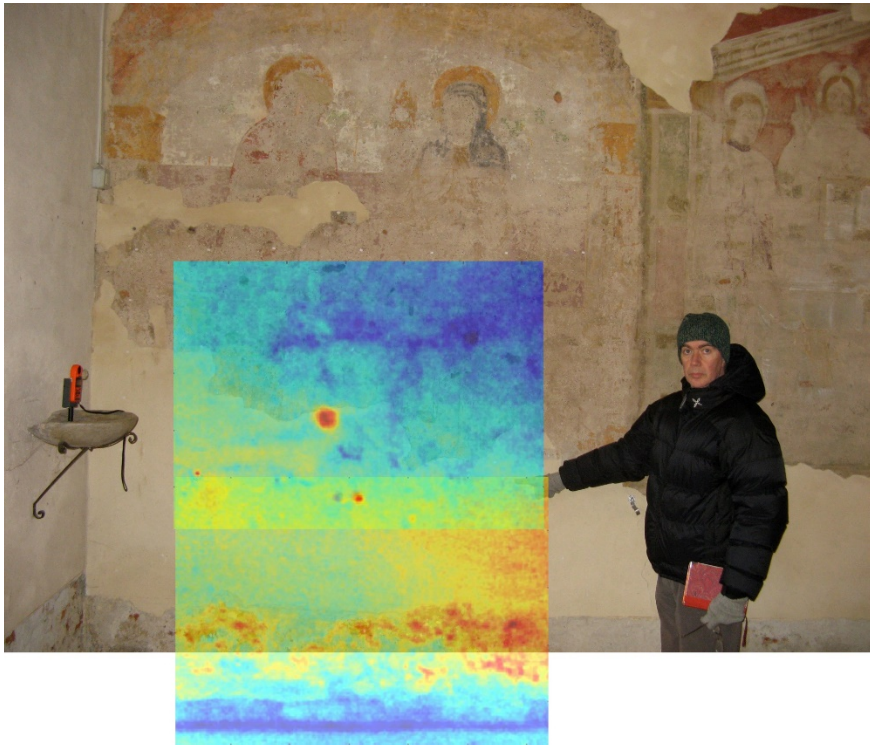
- the investigation steps towards an increasing level of accuracy and effectiveness.

The climatic changes: towards the increase of exchanges in the historic masonry (**alternance of prolonged dry seasons and heavy rainfalls**).

Rising damp is a recurrent cause of damage.

Monitor water distribution and explore causes to support the most appropriate intervention.

Reduction of the risk to apply not effective and expensive products and preventing an oversize intervention.



CLIMATE CHANGES: WHICH RISKS FOR CH

- Increase of temperature (Alps and higher mountain)
- Drought and extreme high temperature (in the plan)
- Extreme heavy rainfalls and hurricanes
- Thicker ice layers, despite of their limited extension

- In Italy, intense rainfalls but decrease of the amount (5-40% in the alps region), the increase of the risk of desertification (up to 20% of the national territory)

- Cultural Heritage, especially the tangible and immovable items, are under risks for many factors.

Mount Kilimanjaro

THE CONSEQUENCES OF CLIMATIC CHANGES ON HISTORIC BUILDINGS

Noah's Ark Project – Global Climate Change Impact on Built Heritage and Cultural Landscapes produced a map of climate, the built heritage, its damages and risks and comparison of past conditions (1961-1990), next future (2010-2039) and far future (2070 -2099).

- In the European region the **change of humidity will increase water content in soil**.

- The alternance of **dry seasons** (with high temperature and no rain for months) and almost **monsonic seasons** (at mild temperature but heavy and prolonged rains), **dramatically affects the distribution of rising damp** in porous materials of masonry, as well as the water content in time.

- The evaporation causes the major damage due to salts crystallization: **fast enlargement of surface damages**.

IMPACTS ON CH (UNESCO 2007)

Table 1 – Principal climate change risks and impacts on cultural heritage, from the UNESCO World Heritage Report 22, Climate Change and World Heritage (UNESCO World Heritage Centre, May 2007, p.25).

Climate indicator	Climate change risk	Physical, social and cultural impacts on cultural heritage
Atmospheric moisture change	- Flooding (sea, river) - Intense rainfall - Changes in water-table levels - Changes in soil chemistry - Ground water changes - Changes in humidity cycles - Increase in time of wetness - Sea-salt chlorides	- pH changes to buried archaeological evidence - Loss of stratigraphic integrity due to cracking and heaving from changes in sediment moisture - Data loss preserved in waterlogged / anaerobic / anoxic conditions - Eutrophication accelerating microbial decomposition of organics - Physical changes to porous building materials and finishes due to rising damp - Damage due to faulty or inadequate water disposal systems; historic rainwater goods not capable of handling heavy rain and often difficult to access, maintain, and adjust - Crystallisation and dissolution of salts caused by wetting and drying affecting standing structures, archaeology, wall paintings, frescos and other decorated surfaces - Erosion of inorganic and organic materials due to flood waters - Biological attack of organic materials by insects, moulds, fungi, invasive species such as termites - Subsoil instability, ground heave and subsidence - Relative humidity cycles/shock causing splitting, cracking, flaking and dusting of materials and surfaces - Corrosion of metals - Other combined effects eg. increase in moisture combined with fertilisers and pesticides

Climate indicator	Climate change risk	Physical, social and cultural impacts on cultural heritage
Temperature change	- Diurnal, seasonal, extreme events (heat waves, snow loading) - Changes in freeze-thaw and ice storms, and increase in wet frost	- Deterioration of facades due to thermal stress - Freeze-thaw/frost damage - Damage inside brick, stone, ceramics that has got wet and frozen within material before drying - Biochemical deterioration - Changes in 'fitness for purpose' of some structures. For example overheating of the interior of buildings can lead to inappropriate alterations to the historic fabric due to the introduction of engineered solutions - Inappropriate adaptation to allow structures to remain in use
Wind	- Wind-driven rain - Wind-transported salt - Wind-driven sand - Winds, gusts and changes in direction	- Penetrative moisture into porous cultural heritage materials - Static and dynamic loading of historic or archaeological structures - Structural damage and collapse - Deterioration of surfaces due to erosion
Climate and pollution acting together	- pH precipitation - Changes in deposition of pollutants	- Stone recession by dissolution of carbonates - Blackening of materials - Corrosion of metals - Influence of bio-colonialisation
Climate and biological effects	- Proliferation of invasive species - Spread of existing and new species of insects (eg. termites) - Increase in mould growth - Changes to lichen colonies on buildings - Decline of original plant materials	- Collapse of structural timber and timber finishes - Reduction in availability of native species for repair and maintenance of buildings - Changes in the natural heritage values of cultural heritage sites - Changes in appearance of landscapes - Transformation of communities - Changes the livelihood of traditional settlements - Changes in family structures as sources of livelihoods become more dispersed and distant

DISASTER PREDICTION/DAMAGE PREVENTION

NATURAL VARIATIONS OF THE WATER CONTENT

The presence of the water can sharply, naturally decrease in the dry seasons, as well as rapidly increases one month or more after the beginning of heavy and constant rain.

The same amount of humidity could affect the same materials with different location:

due to the nature of the soil (clay/draining).

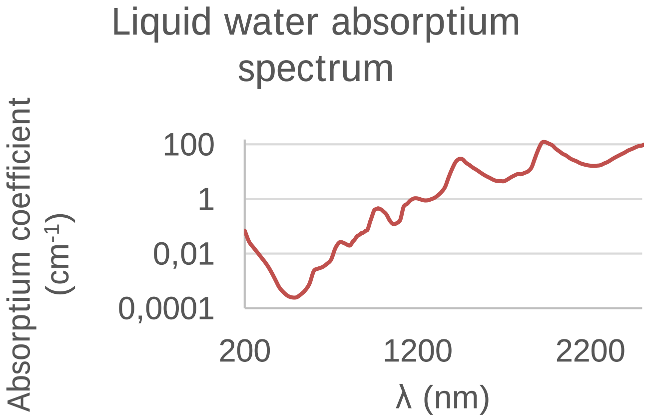
The higher is the variability of the environment change the higher is the time of monitoring (one or more years).

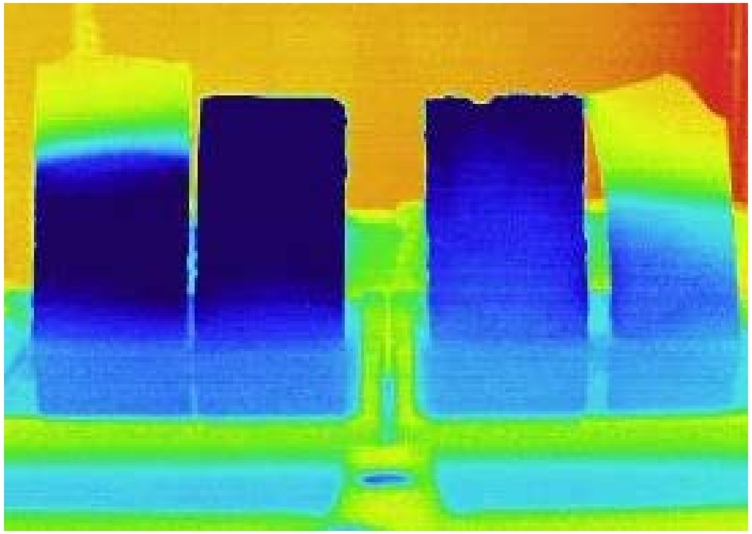
Monitor: Wc, its distribution, T°C air+surface variations.

Venice

2. Methods for detecting water presence and distribution

The conference speakers presented many steady and innovative methods, standards and ultimate results of the research that meet the listed requirements.
The measurements and monitoring is a crucial point for the decision making process. It can be afforded without a robust education, training, experience time and differentiation on historic buildings.
Although the avalaibility of low cost instruments, only research institution, laboratories and companies are the third part to involve in the assessment of the intervention for reducing dampness.





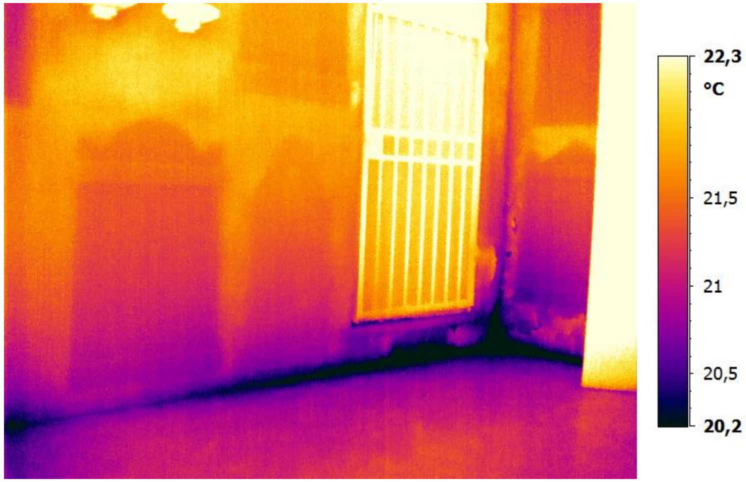
Courtesy of J. Melada, M. Gargano, I. Veronese, N. Ludwig

MONITOIRNG BEFORE, DURING, AFTER THE REDUCTION OF RISING DAMP

These parameters are also the same those, can determine if the water inside the masonry is effectively reducing or not, due to the intervention/application of devices.

Midterm monitoring, before and after any intervention or application of devices, for determining the effectiveness of the intervention.

The aim of monitoring is to exclude not recurrent behaviors, **quantifying the water fluctuations in masonry for identifying the water sources.**



Mantua, Duomo – IR thermography on 24 may 2017

3. DIAGNOSTIC MOISTURE PRESENCE AND DISTRIBUTION

Monitoring for 2-3 years and more requires to adopt non destructive methods.

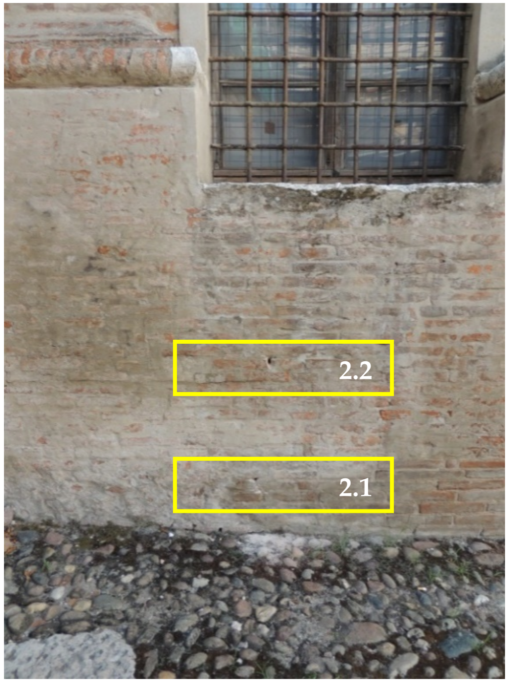
Repeat the tests:

1) without loss of material;

or sampling a few grams;

2) Fast low cost, analysis;

3) to apply both extensively in the preliminary phase and on specific areas in the second phase of the advanced diagnostic.



Punto	H da terra	Wc% 21/06/2017	Wc% 25/10/2017
2.1 S	30 cm	9,9%	6,0%
2.1 P	30 cm	11,1%	4,8%
2.2 S	80 cm	2,8%	3,8%
2.2 P	80 cm	5,2%	3,0%

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EARLY DIAGNOSTICS FOR PPC

On site monitoring depict a broader view of the elements of the building under investigation reduced time and economic support:

fast deliver qualitative out put,

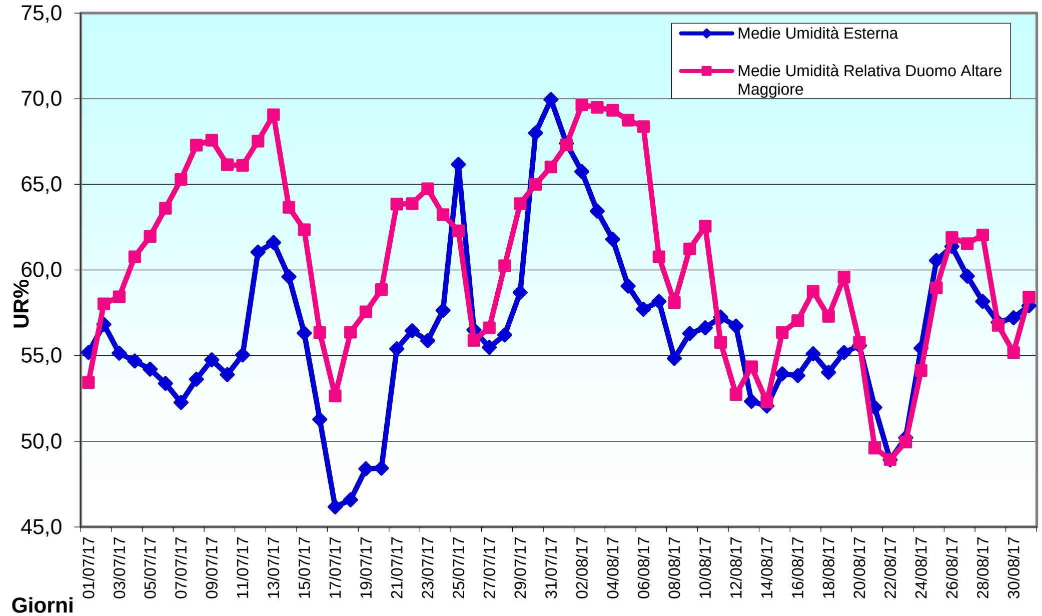
feasibility on wide surfaces.

fast scan working techniques

multispectral analysis: contactless instruments.

Monitoring vulnerability and critical environmental conditions.

Mantua, Duomo – report of RH in july and august 2017

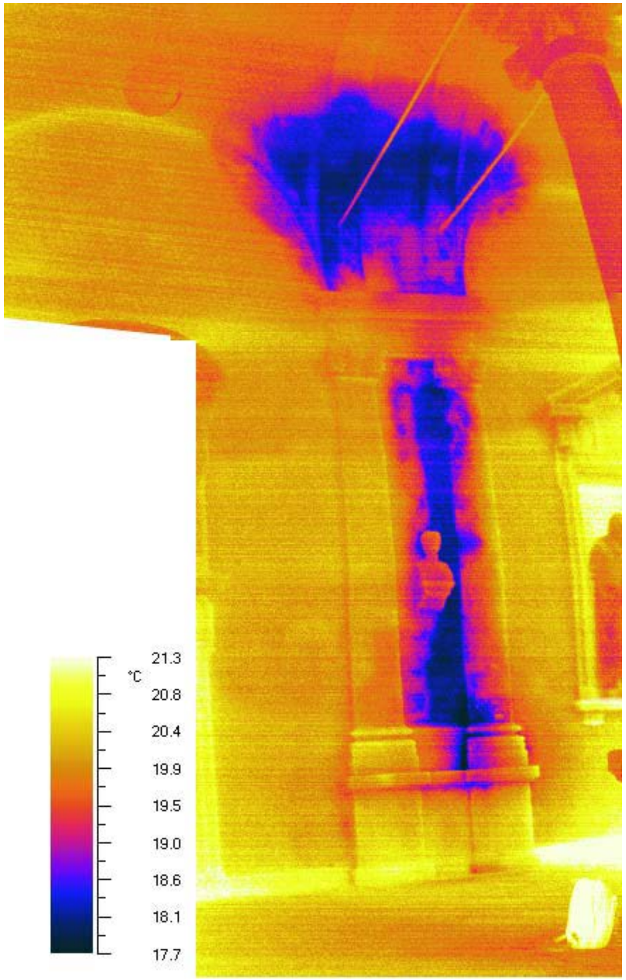


3. LESSONS LEARNED FROM MILAN

BRERA GALLERY IN MILAN, 2011

An example: early June 2011, exceptional storms (wind speed of 40 km/h), very heavy rains.

THE WATER INFILTRATION FROM THE DOWNSPOUT (IN THE MASONRY)



INSIDE THE WATER GATHERING SYSTEM AT THE EAVES

1) Partial obstruction of one of the downsput;

2) refurbishment of the HVAC;

3) Fast accumulation of a large amount of water inside the downspout

caused the breakage of a pillar and the masonry around.

CRITICITIES

1) Building features
2) technical plants

What to do?

- reduce the time of contact between; foundation/masonry and soaked soil (especially if clay ground);
- improve the drainage system from the eaves to the foot of the masonry (hidden downspouts inside the masonry);
- exceptional increase of water amount to quickly and effectively gather and convey into the vertical ducts inside the masonry;
- re-shape and dimensions of the final gathering basins at the edge of the downspouts to drain the hydrometeors.

4. IS MOISTURE CONTENT TO BE REDUCED?

Moisture content remains a risk for the conservation of masonry, especially of the surface, nevertheless the exchanges with air are the real cause of damage, that soon or later will occur although not apparent in the beginning of water infiltration.
Later is the intervention, later is the reduction of damage, in case the cause of infiltration is still active.

How much of historic material in a building is possible to loose before losing its authenticity?

4.1 MAIN CAUSES OF WATER INTRUDING

The observation of the last 20 years shows that rising damp and water infiltration mostly is due to the rainfalls not properly drained by plants (gutters, downspouts and water canalization for water removal from the foot of masonry).

In fact, rain spreading in the soil, towards the depth layers or remaining on the surface ones where clay layers intercept its draining, diffuse also soluble salts inside the masonry materials, due to water sorption.

WHICH ARE THE POSSIBLE INTERVENTION?
AT FOOT ....

The interventions against water intruding the masonry due **to water table or rainfalls** are totally different, although the **damages** caused by both these causes **are the same**.

The screening of the sources and identification of cause/causes will guide the decision to intervene and the choice of the intervention.

The conference speakers showed a wide and deep fan of experimental on the most recurrent techniques in EU, as a result of research projects involving most of the countries. The laboratory and in field experiments showed the result of testing many techniques, with comparable diagnostic tools.

Some of widespread methods available on the market resulted ineffective.

What could be the consequence in the next future of not really effective on the causes? **Is the delay** of proper intervention **a loss in the economic evaluation** of the damage on historic structures?

...AND ON THE TOP

Protecting roof system by periodic inspection and early investigtion, maintenances, care, early intervention (monumentwacht, Monza districts consultancy for PPC, Doctor Building etc...)

The maintenance of rain canalization in historic buildings raise of importance, as well as the protection that prominent eaves can provide:

rethink the typological and philological criteria to avoid any visible rain ducts or to avoid to reshape the roof protunding and slope.

PREVENTING DAMAGE/MITIGATING THE ENVIRONMENTAL RISKS

Courtesy of the students of Conservation class ,Politecnico di Milano, Polo di Lecco, y. 2017/18

AND THEN,
LET IT RAINS!

https://www.youtube.com/watch?v=W4u8cwyvfOI