3rd MANILA WORLDTEX 2001 - PHILIPPINE

March 14th – 18th - 2001

INTERNATIONAL SEMINARS

PRESERVATION AND RESTORATION OF ANCIENT BUILDINGS
The role of the new technologies between “simulation” and “real intervention”

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published in Manila – Philippine
March 2001
THEORETICAL PREMISES

Since more than two centuries, at least, the European culture has been discussing about the destiny of the ancient monuments fortunately still existing in our cities and landscapes. They are the fragments of an impressive material and spiritual heritage, the precious trace of an ancient and sometimes unknown history. They represent not only a “material good” to be transmitted to future generations but also one of the most important signs of our cultural and social identity.

For these, and other reasons, our monuments (ancient or recent) are not mere “buildings”, they are more important than a simple product of the constructive capability of our grandparents. Churches, temples, noble palaces, mills, and so on, are, first of all, an incredible “mine” of knowledge, of “direct” information, not only useful to understand the “past” but also to design our “future”.

Just for this reason, since more than two centuries, we are struggling to impose different behaviours in this field and to give the final prominence to different words, such as “conservation”, “preservation”, “care”, on one hand, and “restoration”, “renewal”, “revitalisation”, “appraisal”, on the other hand. This struggle is in fact intended to define and to decide the destiny of the ancient monuments and towns.

The “Coliseum” in Rome
Interventions by Raffaele Stern (left) and by Giuseppe Valadier (right) – early XIX c.

“Preservation” versus “Restoration”

New forms, materials and structures (left) - new materials and structures with ancient forms (right)

Starting from these antithetic words and from their “concrete” results for the interventions on existing buildings, I shall try to suggest a way to escape from the paralysing effects of this ancient struggle.

We can easily note, in fact that, behind the words, there are different intentions and that “what we say” can really bring to different results that we can not compare and can not exist in the mean time. Different words correspond, in fact, to different actions, but different words can exist together, giving life to a contradictory dialogue, while each action eliminates all the “possible” others.

The struggle between terms like “conservation” and “restoration” is as ancient as the debate on the destiny of architectural heritage. During the XIX century, for instance, Violet Le Duc said that: restoring it is not preserving a building, and it could mean to bring it again to a state of wholeness that could never have been existed… Almost contemporarily, and with a completely different attitude, John Ruskin said that: restoration is a lie, the worst lie linked with the destruction of the beloved artefact…, because it does not ensure the existence of the ancient monuments, for the future generations. In fact, it changes the monument in such a way that, at the end of the intervention, it will deal only with the work, the age and the culture of the restorers, and not with those of the men that created and transformed during the history.
As we can easily understand these two “fathers” of the modern architecture and of the modern “restoration theories” express two completely different and antithetic ideas about what we have to do of our ancient monuments. They are different ideas that still exist and always influence the projects of contemporary architects and restorers.

“Preservation”, “Conservation”, “Restoration” and “Innovation”: different words and different meanings

Our landscapes, our cities, and even a great number of our monuments, or simply of the buildings deriving from a far from past, are a complex whole of different things, the results of various actions (non only constructive ones, but also destructive), of different willing, intentions and desires. They are often the casual stratification of materials, of forms and traces of ancient uses, which has been put all together by the long river of an almost unknown history. And we can only hope to be able to discover and to re-construct this history just starting, from its material remains (our landscapes, cities, and monuments, by the way) as from precious and sincere documents, direct tests of what happened in the past centuries.

If all this is true, we can not solve the problem of what we have to do for the future of our heritage reducing it to a simple struggle between the willing of a new asset or the respect for the existing one. All our history, and that of our cities and monuments, is deeply marked by constructive and destructive actions. What we now possess as an Heritage, is only a small part of what other men before us produced during their lives and of what an impressive number of generations co-operated to build, destroy or modify, transforming the world of the nature into a world of the man culture. Therefore, we can not state, in a
definite way, that everything now existing must be conserved or preserved, nor that it must be destroyed, modified and substituted, every time a generation passes over.

What to do of our heritage is, every time, a difficult and responsible choice of any generation, of any community, of any nation and social group. It is a choice that signs our identity, our place within the long river of the human history and civilisation, and it is not a simple matter of technical discussion but of a deeper cultural nature.

For this reason, it is not correct or useful to continue asking, as a lot of us do, why we can not make as all the other generations made before us, using, consuming, changing, destroying or modifying the buildings they received from previous generations. We must in fact remember and recognise that during the last two centuries our world and our civilisation knew such deep transformation as never happened in the previous ages. Industrial, economic, social an political changes has been so revolutionary, since the period of the French Revolution, of the “illuministic” and “positivistic” age, that we now live in a completely different world, compared with that of our grandparents. Everything they constructed and left us, as a provisional heritage, is thus a sort of irreproducible fragment of a lost reality. If we waste our landscape, our cities and monuments we can not hope to find them again in the future: they will be lost forever and nobody, after us, will never have the chance to contemplate, to study, to use them any more.

The destiny of our cultural, artistic, architectural and environmental heritage, for these reasons, represents a great responsibility for ourselves that we can not ignore or escape, in any case: our sons and nephews will ask us reason of our attitude and behaviour in this field.

So we must go on, leaving the simple struggle between those who always want to change, to modify, to destroy and substitute little fragments or large parts of our present landscapes, cities and monuments, and those who always hope to preserve everything. We can not pretend to stop the course of natural and human events. We have, on the contrary, to choose every time what to do in front of the power of nature, that tries to conquer again the fruits of the human work and culture, and the whiling of the men, which desires to better their environment and the spaces where they live. In this difficult choice we must remember, in any case, that what we destroy will never exist another time, it will be lost forever. We do not know exactly what we administrate, we can not say, in any way, that it is not full of precious things for the study of the past, for the use of its values and resources, but also for a better future. So, the destruction, and even a restoration that deeply modifies an ancient monument in the strange attempt to reach again a state definitely lost, could be a real and irreversible lack of chances and resources.
Ancient Paleochristian Churches in Rome before (up) and after (down) the restorations carried out at the beginning of the XX century (S. Maria in Cosmedin - left – S. Sabina – right)

The search for an ancient and lost magnificence brings to others losses and to real inventions
What will remain of the “true” past, after these kinds of interventions?

We must therefore think to this aspect of the problem, to this possible danger and damage, before doing anything: it is not a duty, not a metaphysic or ethic law, it is simply a call for prudence, for a responsible and thoughtful action.

For John Ruskin, we have to accept the destiny of death that belongs to the men’s work products as to every natural being. This means that we can not restore a monument, at least if we intend for restoration the desire and, in the mean time, a series of operations that tries to go back in its history, modifying its materials, its forms, its aspect or structural behaviour, looking for a lost state. We must, on the contrary, respect all the signs that the passage of the natural times and of the human events have left upon the surfaces and inside the body of the ancient building, even if, or just because, we do not know them in a complete and satisfying way. Those signs deal, in fact, with the “true story” of the monument and with that of the men that constructed and modified it during the past ages (even if this “true story” is now hidden and partly unknown). We have, therefore, to “take care” of our monuments, as a precious source of culture, of knowledge, of technical skill, contrasting all the perils and the actions that could damage or destroy it. We can only make all the possible efforts to ensure it a longer life, stopping, in any case, in front of any temptation of transforming it in a sort of “fault” simulacra of itself. In this case, in fact, “restoration” would not mean real care and defence of our monument, but only its irreversible “falsification” and destruction.

“S. Maria del Fiore” Cathedral in Florence – XIII c.

As it was in the XVI century (left) and for the restoration project of the XIX century (right)

The search for a “balance” between care and innovation often creates new structures with ancient forms, but also destroys the ancient state of the monument.

So, we can not decide if everything coming from the past must be “conserved” or “restored” (that is, “preserved” or “modified, integrated, substituted”… and so on), also because both perspectives are, in the space of one single generation, really impossible. We must only be conscious that where the care for conservation or preservation stops (because we decide it is impossible or not convenient or for other reasons) the space of new design and of new architecture begins. There is no space, in fact, for a strange balance between the needs of the preservation and those of the innovation. Where one stops, the
other begins, even if the boundaries between these two fundamental activities are not always clear and easy to be fixed. Other problem is to decide if the new architecture will be made of new and “never seen” forms or if it could follow ancient rules or “reproduce already seen solutions”. It is, of course, a matter of discussion and every chance is the result of a free choice and not of an obliged behaviour. This is important, because if it is a matter of decision, we must assume all the responsibilities about it, renouncing to invoke strange reasons to diminish the real impact of our free proposals. In other words, restoration as a sort of “noble mix” of preservation and innovation, represents a bad compromise, a not solved contradiction, an impossible solution of opposed aims.

How to decide and how to control the results of our choices

We certainly can not solve this dilemma during the congress, but it is important to start from the consciousness of this problem. Only in this case, in fact, we can understand “why” and “how” the new “Information and Communication Technologies” could help us in the attempt to move behind the problem, hoping to find new reasons and new methods for the defence of the ancient vestiges of our civilisations.

In any case, in fact, if we use the term “conservation” (in its whole meaning), but also if we prefer to use the word “restoration” (with all its contradictions), we need “to know” the objects of our care and “to control” our decisions and their technical results.

I shall try, therefore, to show how modern technologies and, first of all, the use of informative systems (Alfa-numerical, digital, analytical, raster and vector…) could change our traditional attitude about the problems involved by the care of our architectural and environmental heritage.

The following pages will particularly deal with the possible, and already experimented, use of similar technical devices in the following fields:

- non destructive analytical methods for the studies of ancient buildings (physical and chemical characterisation and determination of the mineralogical and petrographic nature of the materials; recognition of the traces of work-processes and transformation…)
- diagnostic techniques for the recognition of the decay phenomena and for the evaluation of the conservation state of ancient materials and constructive elements;
- predisposition of graphical and technical elaborates for the project of intervention on ancient monuments;
- simulation of different technical solutions for a single problem, to evaluate possible alternatives of intervention and to control their results, in a sort of “virtual reality” that allows us to decide in a more meditated way, avoiding the risk of improper destruction and of dangerous damage of the ancient monuments;
- construction of a new instrument to aid the work in the construction-site, guiding the actions of technicians, professionals and simple workers.

THE ROLE OF NON DESTRUCTIVE ANALYSIS AND TECHNIQUES

When we speak about the studies on existing architectures we often ignore that they could assume two different meanings and, under a certain point of view, two dialogical aspects. The first aspect considers analysis like a simple instrument to collect various kind of information practically useful for intervention. Among these analyses, are those regarding structural defects and disease, the forms of mechanical, physical, chemical and biological degradation of the involved materials, or those directed to recognise the materials or to control the environment. The second aspect of the studies on existing architecture, on the contrary, identifies the analysis with a precious chance to “understand” historic buildings and to open new perspectives for knowledge itself. Stratigraphical and archaeological researches, historical inquires, geometrical measurement, as many others studies, belong to this second kind of attitude. Meanwhile, when we deal with analysis in the field of diagnostic studies we often forget to distinguish these two different ways of thinking and operating. For the same reason, we generally use the expression “knowledge” without considering that ancient monuments are built with materials belonging to the “universe of nature”, but also with forms, ideas and instruments belonging to the “artificial universe of human culture”. We cannot make confusion between these two levels of problems and we must not reduce ancient buildings to a simple sum of physical or chemical phenomena. On the other hand, we cannot give absolute prominence only to the exterior and formal aspects of the monument without considering its material, structural and constructive consistence. Ancient monuments and historic buildings are the precious sign of our past, they are non-replaceable fragments of our cultural heritage and their future depends on our attitudes and actions. For this reason we must study ancient buildings to understand their conditions, their problems, but also their values and meanings. A great aid to achieve this result can derive from the wide and complex technological and scientific field of the non-destructive techniques, which are today available for the analysis of architecture.

The “Specialisation School in Monuments Restoration” of the University of Genoa, has applied various methods of diagnostic and non-destructive tests in the field of architectural conservation. These experiences, lasting from various years, regard several monuments of our territory, among which are ancient castles, churches and noble palaces. Every time we tried to study and understand the characters of these ancient buildings, we used both empirical and scientific methods, sure that not only
the second ones could be rigorous and useful for our needs.

We never forget, in any case, others forms of diagnostic studies necessary for a correct project of restoration, such as the historical and archives researches, always used as dialogical data for verification of the results obtained from the previous methods. We try, for this reason, to put in a continuous dialogue all the instruments that traditional methods and contemporary technological development, offer us to sustain our efforts for the care of architectural heritage. The real problem, in fact, is that of the organisation of all the different enquires, of the numerous tests and of the different surveys. This, to obtain: a) a correct use of economic and technical resources, both in the analytical and in the practical phase of intervention; b) meaningful results, regarding our study goals and intentions; c) a real advancement of knowledge, in all the different cultural fields involved in any study-case.

But beside the non destructive techniques for the analysis of ancient monuments, in any case, are now those for the control of the interventions for their future state and destiny, and we can not ignore these new boundaries of our contemporary world.

“Simulation”, “visualisation”, “virtual reality”, and so on, are today’s activities, even if they probably have ancient roots. Their first rational use, probably, dates back to the perspective invention, but the studies about the description of the space, pass through the basic contribution of Desargues and Descartes, in the field of projective geometry, come to the descriptive geometry, by Gaspard Monge, and evolve with the Lambert’s prospective transformations, with Laussedat’s and Meyedenbauer’s photogrammetry, to get to the never ending multiplicity of digital world. Painting, literature, theatre architecture...are just some of the regions of “representation”, that means that universe of reproduction which performs an extraordinary combination of real or imaginary space-event, simply imagined and created, or concretely built and transformed. For this reason we can try to work upon the chances that these instruments have to be applied also in the field of the care and preservation of our Heritage.

OUR RESEARCHES

The “School of Specialisation in Monuments Restoration” of the University of Genoa was founded in 1994 and is one of the five now operating in Italy. Its institutional finality is: “to provide a specific professional preparation in architectural preservation, complementing the university studies, and to allow achievement of a wider and more extensive knowledge of methods and techniques for the protection and conservation of architectural and environmental heritage”. Through its educational function, the School offers, therefore, a contribution to the community commitment towards conservation of historical heritage, because an essential part of the solution that can be given to the problems of protection depends on the presence of operators in possession of adequate theoretical and technical preparation.

It is well known that restoration involves a plurality of subjects able to operate at various levels of execution. This activity requires performing skills, which include: a) the many types of preliminary investigation for the analysis of the buildings; b) the also numerous techniques of careful operation on degrading; c) the production of materials for the restoration; d) the means for the administrative, financial and executive management of the building sites; e) the quality control of the results, and so on.

It is therefore necessary to conceive a typical operator who, after acquiring an adequate university instruction in the field of architecture, has also received a deep and specific theoretical and practical preparation in the field of preservation and restoration.

The main target of the School is, therefore, to go beyond the classical academic teaching patterns, which are sometimes abstract in content and based on a hypothetical reality, to achieve concrete results which can be pursued if the didactic possess solid and realistic bases.

For this reason, in an attempt to make the training more realistic, studies and projects are always related to a real objects; historic buildings with a customer that intends to use the results of the analysis carried out by the School.

We can thus say that there is a great number of study-cases which testify the activity carried out by the School and, moreover, the achieved results have a great scientific and technical interest for our future research in the field of analytical and diagnostic non destructive tests.

In fact, besides the historical and theoretical components illustrated in the various courses, the School aims at a technical and professional preparation that, for the analytical part, foresees the following experimental activities:

• **Morphological analyses** using: manual, topographical and photogrammetric surveys, geometrical checks and topological investigations, for the knowledge of general and particular forms of the monuments and of their components, but also for a correct diagnosis of their conservative conditions and of their structural behaviour (static and dynamic control, with passive techniques);
Architectural survey of Trento Cathedral

Sketch for field survey operations, topographical net for the general survey of the church and the principal facade from photogrammetric restitution

- **Morphological, physical and diagnostic inquiries** using: image processing techniques for qualitative and quantitative analysis of materials and constructive elements, for recognition of ancient treatments and of constructive techniques but also of decay phenomena (pattern-recognition, image-analysis and image-processing, video-endoscopy, geo-radar prospections, ultra-sound tests, thermograph applications, special photography – IR, UV, and so on);

- **Geometrical and structural studies** carried out with the aid of computer aided models photogrammetric surveys, solid and wire-frame models, 3D models, DTM and so on);

- **Chronological analyses**: archives investigation and historical research, dating, techniques, archaeometry, architectural stratigraphy, carried out with the help provided by our “Archaeological laboratory”;

Different results of various kind of analytical analysis

*From left to right: endoscopy, U.V. fluorescence, lateral lightening photography*

Wire frame models for structural studies

*Villa Bombrini in Genova, monumental staircase (left) – Trento Cathedral pillars (right)*
Archaeometric dating techniques
Methodological schemes for: dating timber elements (left) – recognise stratigraphic relationships between constructive parts of a building (right)

- Material analyses carried out using: empirical investigations and chemical, physical and mechanic characterisation laboratory methods (throughout: Optical and Electronic Microscopy, - SEM -Diffraometry RX, Cross Section Analysis, Chemical characterisation with laboratory routine methods, like Volumetry and Titolation, Turbidimetry, Conduttometry and so on or with advanced devices – like, Electronic Microsonde Analysis)

Cross-section for material analysis
Methodological scheme for the preparation of samples (left) – microphotography of a cross section from the Perseo Statue by B. Cellini in Florence (right)

- Analysis of the decay phenomena and of static instability, using: empirical and laboratory techniques, (to recognise and characterise deterioration phenomena), like: image processing techniques, empirical characterisation scientific inquires with laboratory tests; measures of humidity; analysis of biological deterioration; analysis of physical and mechanic alteration (through non destructive tests, in situ or in laboratory).

Degradation and alteration analysis and diagnosis
Cross section of a decayed stone in S. Pietro Basilica in Rome (left) – microphotography of the crusts existing on the bronze statue of Perseo by B. Cellini in Florence (right)

Scientific and technological aims

In all these different activities, we always use integrated systems of operative instruments and techniques for the:

- editing of restoration projects,
• preventive check of its results (virtual restoration);
• monitoring of qualitative and quantitative realisations.

For all the above mentioned reasons, our didactic and experimental work, always intends:
• To experiment innovative technologies for the restoration projects, through the development of the process currently in use, with the support of virtual reality (previsions, in similar shape, of the results) and image processing resources. We have also the purpose to emulate environments generated from historical reconstruction, formal and material integration, building variations.
• To use simulation methods for conservative operations, to estimate the planning choices and the compared study of alternative solutions.
• To adopt special visualisation technique: (simple and matched strengthening of normal photos, pattern recognition, computer vision, 3D rendering and modelling, automatic transformation of raster images into vector and digital images, editing of interactive thematic maps), just to obtain a continuous comparison between the information acquired in the analytical work, the choices of intervention and the relative tenders and estimates.

The “Rapallo Castle” – Ligurian coast near Genoa – XV c.
(from to-left to bottom right: general view, graphic restitution of the photogrammetric survey, interactive thematic maps for the analysis of the materials used in the monument and of the decay phenomena affecting it.

Within the last experiences we tried, right for this reason, to experiment innovative technologies for the architectural restoration project, developing the practices commonly used in that field, also with the employment of different resources offered by virtual reality techniques.

We want, in fact, to evaluate different solutions, both under a quantitative point of view (for example: size and costs of works), and under a qualitative point of view (i.e. correctness of technical practices and preventive analysis of the results).
To reach this general goal we use advanced survey methods, image processing techniques, and relational databases in the following fields of application:
• Editing of interactive thematic map, describing, in real-time, quality and quantity of building materials, of degraded surfaces, and restoring operations.
• Simulation of conservative operations in aim to prevent them in virtual form and make results verifiable.

The current studies in this field, in fact, are usually oriented to solve specific matters by expensive and difficult technologies, only manageable by extremely skilled workers. On the contrary, we try: a) to give organic solution to technical practices the restorer should choose during the planning stage to previously check the results. b) to make available to the largest part of enterprises and professionals in this field, the access to these methods with a reliable scientific basis and, at the same time, widespread and easy-to-use practices.
These innovative contents may be reached by operating, above all, in the following sectors.

The role of Architectural Surveys Techniques
Since several years, hardware/software equipment which enable to survey buildings throughout simplified digital photogrammetry, suitably integrated with elementary topographic operations, are available.

It is a matter of remarkably versatile processes, which do not need any high specialisation and put themselves into a middle-space, between the old and rough direct survey practices and classical analytical photogrammetry (which needs an high competence level).

Digital photogrammetry also allows metric 2D (simple and matched strenghtening) and 3D (modelling and rendering, DTM, contours) plotting.

These technologies combine a relative ease of use with an affordable installation cost for middle-low dimension offices; in association with simulation techniques and informative systems, these methods can reach a more elevate processing ad information power.

A palace in the historic centre of Genoa, along a very narrow street

An example of application of digital photogrammetry (based on the strengthening of normal photo - lefts) for architectural survey and the related restitution (mosaic of strengthened photos) - right

The space for Visual Technologies

Plottings will be considered as a base and a support of an articulate system which should enable to manage, in an interactive way, geometric data (the above-named surveys), material analysis, decay and failure phenomena diagnosis, historic data, archaeological and stratigraphic readings results, sharp distribution of interventions.

Also the "thematic maps", which are usually used for the restoration projects, can not be reduced to a passive description of the objects. They must be considered as an “active” system, to give simple and/or crossed answers to the over mentioned problems, to allow estimate checks about the project tier, to estimate the quantities and the costs of the interventions.

In this field tri-dimensional models management and editing, the creation of rectangular (DTM) ant triangular (TIN) mesh grids, the creation and visualisation of chromatic models, automatic contours plotting, the creation of ortho-photos, are included.

Image processing and simulations techniques for the restoration project

We need, therefore, to extend to the Cultural Heritage conservation the different processes already successfully applied in medicine, metallurgy, forestall sciences, in pollution studies and other disciplines.

The sector’s specialists are involved in giving a solution to these crucial questions on conservation, but the actual studies are generally oriented towards specific solution to separate questions, with expensive technologies an anyway available for particularly skilled workers. As it is well-known, image processing allows a wide range of operations, like contour tracing, image segmentations, pattern recognition techniques, automatic vector or raster images transformation, an so on.

We have, in this field, a lot of operational consequences, because the described technical devices can be applied to the materials and decay phenomena recognition, to various types of intervention’s simulation, to virtual reconstruction of historical environments, or to integration, completion, and liberation virtual attempts. Such operative consequences are possible, anyway, if the digital treatment techniques are put in functional correlation with the 2D/3D modelling techniques and to an informative system that can rule the whole of the data involved in simulations and visualisations for a restoration program.

A case study: the painted facades of Albenga ancient hospital
Architectural survey throughout digital photogrammetry

*The basic photos of the facade (up-left) and the same photos after the digital strengthening (up-right)*
*The general mosaic of the strengthened photos (bottom)*

Examples of image processing treatment of some photos of the plaster facade, for the recognition of the traces of the ancient frescos

Simulation, throughout image processing methodologies, of a possible solution of the restoration program with the integration and the conservation of the ancient frescos decorations