



Chair:
Prof. Carolina Di Biase

DOCTORAL PROGRAM IN PRESERVATION OF THE ARCHITECTURAL HERITAGE

The PhD programme in "Preservation of the Architectural Heritage", first activated at the Politecnico di Milano back in 1983, is organized in a renewed form. In addition to the professors of architectural restoration, history of architecture and structural strengthening of the Politecnico di Milano, the Faculty Board includes representatives from other well-known universities and research institutes (professors of the Università di Genova, IUAV, Venezia; experts at the highest level in the field of preservation of cultural heritage and of the administration of cultural heritage in Italy: Istituto Superiore per il Restauro e la Conservazione ISCR, formerly Istituto Centrale del Restauro, Soprintendenza Regionale della Lombardia); they collaborate actively in the teaching and research activities.

The ultimate purpose of the Faculty Board not only resides in broadening the experiences that the PhD candidates acquire over the first three years of the course, where they have the opportunity to interact with scholars from different backgrounds; it chiefly aims at providing the PhD candidates with a unique training experience in the Italian panorama, so far unparalleled also in domains other than the preservation and restoration of the cultural heritage. Such context, where different traditions and approaches are compared, investigates the synergies and responses to the modern themes of cultural heritage protection.

The PhD programme is meant as the place where theorization, methodology, investigation into the most significant chapters of the protection of historic architectural and cultural heritage are connected to complex, challenging operating research themes, on-site and lab experimentation of analytical and diagnostic stages and, finally, the experimentation at building sites which cater for the foremost Italian works.

The relationship with Italian Ministero per i beni e le attività culturali e il turismo, Mibact, has been definitely fruitful, especially when we consider that many among the best PhDs in Preservation of Architectural Heritage have been hired as officers and executives to the above ministry.

Teaching aims

The Faculty Board organization allows to investigate and share extremely relevant, up-to-date topics that, architectural heritage being the high spot of research, describe the complex domain of preservation, a strategic field and, at the same time, one of the chief resources of the Italian economy and future. Being a mix of differentiated research, experimentation and

operating methods, the PhD programme provides the candidate with a rich and very interesting experience.

The on-going contact with the breakthroughs from studies and research carried out in Italian and international contexts and the will to promote joint projects are fostered through expanding the network of relations the university entertain with other universities and research centres in different geographic areas of the world.

In this regard, over the past 3 years the PhD programme in Preservation of the Architectural Heritage has been committed to promoting and coordinating inter-doctoral courses contributed by foreign professors from different European countries (lately the Course of the PhD School *Tradition and Perspectives of Polytechnic Culture in Europe*).

Such activity will further benefit from the co-operation with other PhD programmes in the Politecnico di Milano and the universities that collaborate with the PhD programme activities.

Coursework

The PhD programme, lasting three years, calls for the acquisition of 180 credits overall.

Thirty credits are concentrated in the first year and are divided as follows: 25 (minimum) offered by

PhD courses organized by the PhD programme in Preservation of the architectural heritage, and 5 credits offered by the PhD School.

The academic plan of the PhD programme revolves around 5 main research areas:

1. Preservation culture and practice; 2. Diagnostics of materials and structures and rehabilitation of historic buildings; 3. Methods and themes of historical research; 4. Construction history; 5. Historical territory and landscape.

The remaining credits are aimed at personal study and research for the PhD thesis. Moreover, for each PhD candidate a specific study path is organized and PhD candidates may attend courses offered by the School for Specialists (Scuola di Specializzazione in Beni Architettonici e del Paesaggio - SSBAP) in Milan and in Genoa, in relation to the various topics of their thesis. The activities undertaken during the second and third year also include attendance of workshops, seminars, national and international conferences

related to individual research, with great attention to conferences wherein PhD candidates present the results, even partial, of their research theses.

Research organization and topics

Educational activities are related to research either under way or at an early stage of development, some of which addresses major monumental structures and some of the most renowned sites of the world.

To the aim of their thesis research, PhD candidates have the opportunity to rely on facilities and laboratories, both inside and outside the University, the breadth and width of which provides them with a crucial support to the aim of acquiring "competence for highly qualified research activities" in the domain of cultural heritage protection.

In this connection, the PhD programme deems to carry on the long - standing collaboration with the ICVBC-CNR (the Institute for the Preservation and Enhancement of Cultural Heritage) "Gino Bozza" Unit, Milan. As for the thesis research, candidates thus have the opportunity to address and investigate in-depth the wide-ranging themes connected to heritage knowledge and preservation broadly meant, such as advanced methods of investigation; knowledge management and preservation processes applied to historic buildings tradition, as the ones presented here and related to the archaeological sites and remains (Ottoman Bath's from 13th to 16th century in seismic areas, **fig. 1**) or to twentieth-century heritage (the thesis concerning the structural experimentation on high-rise buildings in reinforced concrete in era of fifties and sixties, and the analysis of their performance in relation to the current

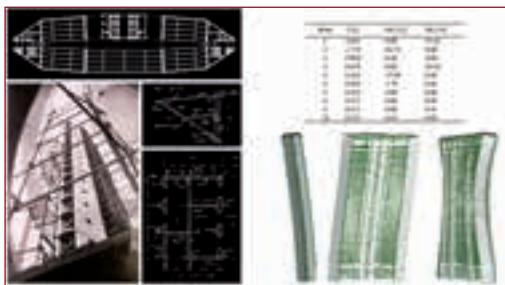


1. Ismail Bey Bath, south west view

design code requirements, **fig. 2**); or to critical and historical investigation on museological and museographical issues, as deepen in the research dealing with the refurbishments of the Pinacoteca Ambrosiana in the first half of the 20th century (**fig. 3**).

This aspect increases the technical characteristics, and will make PhD immediately competitive at the European level.

The multi-disciplinary nature of the doctoral courses, encouraged in the framework of the PhD programme since its establishment, equally values the fundamental contribution of historical research alongside its methods (see the thesis on encaustic painting in Mantua, Verona and Cremona between the 18th and 19th century); at the same time it features innovative, pioneering themes: research about the energy response of buildings targeted to the reuse of existing



2. The Pirelli building: from the archives to the numerical model.

technical systems and to reducing the impact of new systems which, since long, have been extensively addressed by the PhD programme and at the heart of an International exchange with European universities and research labs; the research about BIM technologies applied to architectural heritage, as evidenced by “Building Information Modelling for the current architectural heritage, or the studies carried about the seismic vulnerability of buildings, which will be keyed to investigating the cognitive methods underlying the “Guidelines for the assessment and reduction of the seismic hazard the cultural heritage” (Ministerial Circular n.26 of 2nd October 2010, D.P.C.M. 9th February”).



3. Pinacoteca Ambrosiana, Raphael room - on the wall drawings by Pellegrino Tibaldi (around 1960s), in Storia dell'Ambrosiana. Il Novecento, Arti Grafiche Amilcare Pizzi, IntesaBci, Milan 2002. By courtesy of Intesa Sanpaolo.

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Invited experts:

Caterina BON VALSASSINA, General Head for “Research and Education” at the Ministry of the Cultural Heritage and Tourism (former Regional Head of Architectural Heritage and Landscape of Lombardy);
 Gisella CAPPONI, Head of the Istituto Superiore per la Conservazione e il Restauro ISCR (formerly Istituto Centrale del Restauro) Rome;
 Andrea ALBERTI, Head of the Department of Architectural Heritage and Landscape for the territories of Brescia, Cremona and Mantua.

WOOD AND EARTH ARCHITECTURES IN NORTHERN ITALY FROM ROMAN TIMES TO THE MIDDLE AGES: The transmission of knowledge brought the archaeological record

Anna Antonini - Supervisor: **Prof. Alberto Grimoldi**

Wood and earth have historically been the first rough materials to be used in construction. A long tradition of studies, considered Romans to be stone and brick builders. And this could not be denied, as most of the Roman monuments we are used to visit all over Europe are magnificent work of art in stone and bricks. But, going down in nowadays excavations, a different panorama could be traced. Since 1983, when the congress Architectures de terre ed de bois showed that in France, Switzerland, Great Britain and Germany wood and earth were used as building materials even in luxurious domus, excavations demonstrate that romans were good constructors even with perishable materials. Actually we could find traces of this phenomenon just reading classic authors. In Italy the discoveries made in the rest of Europe on perishable materials delayed to be assumed, but they are now currently accepted and considered in almost all excavation reports. Some important synthetic papers on this topic for the roman period appeared in the first 00 years. From this statements started the wish to deepen the use of perishable materials in construction between the roman period and the Middle Ages.

We define perishable materials organic elements like timber or reed, and plastic elements like mud, earth or clay. The thesis presents the analysis of a census which aim was to map building techniques in perishable materials. The archaeological findings considered are dated from the 2nd cent. BC (Romanization) to the end of the 12th cent. AD. Particularly reference were made on the Official Journals of the regional boards of the Italian Ministry of Culture. The Regions considered are the actual Piemonte, Lombardia, Liguria, Veneto and Emilia Romagna, which correspond to the roman Gallia Cisalpina. These kind of sources guarantee homogeneity in the accuracy of papers, but they don't give a good quality of data that has been deepened case by case. One of the problems that the research had to face was the reliability of the archeological record, which has been evaluated in the analysis. The census conducted in Northern Italy on edited excavations revealed 305 evidences of the use of perishable materials in construction. The subsequent step was the development of a standard vocabulary in order to isolate the common technical features of each record. The almost endless

variety of building techniques that excavations revealed, made compulsory the need to create groups of evidences. A classification based on groundwork techniques lead to the isolation of different technological groups. The data recording presented in the thesis allowed to identify five technological groups for the Roman period. Here are shortly described. Group 1: layers foundation post fast Group 2: masonry footing and timber structure 302 Group 3: masonry footing and earth structure Group 4: earth fast posts Group 5: timber framed structure The individuation of the technological groups here described bring the Northern part of Italy in strict connection with England, France, and Germany. This tradition in domestic building, which we couldn't call "of subsistence". This tradition in domestic building, which we couldn't call "of subsistence" because of the use of technologies that presume a precise production cycle, seems not to have disappeared in Northern Italy. As in most part of Europe, even in Italy, with the end of the Roman empire, something in the way of building, changed. No more huge public buildings like stadiums or amphitheatres,

and, in domestic architecture, a change in the way of living: houses became smaller and less articulated, even probably in upper classes domestic architecture. And all around Europe people built mostly in perishable materials. Why? This was probably the first question that medieval archaeologists tried solve since their subject was born. The first and most common answer was to blame on barbarians population that destroyed the Roman technology. In Italy this idea was very well established for two reason. Firstly because of the monumentality of roman sites and their excellent preservation state and secondly because the stratigraphic method was applied later than in other countries and some archaeological evidences were ignored. In this situation the technological gap between the Roman period and the Early Middle Ages seemed to be huge, and this allowed the spread of discontinuists theories, that are still ongoing nowadays. This situation allowed many archaeologists (and historians too) to presume that barbarians generated a great loss of technology. But since the end of the 70's these theories have been rejected and the "theory of continuity" gain popularity. In Italy the problem was faced when the medieval archeology

was born, in the middle of the 80's. Since then many scholars studied the way of building of medieval population and some synthesis have been made on perishable material buildings. The census here presented took in consideration all these previous proposal and propose a new subdivision in technological group: Group 1: masonry footing and timber structure Group 2: earthfast posts Group 3: timber framed structure In this perspective it became possible that there was a technological continuity with the Roman period in the use of the same foundational techniques and, in the preserved cases, even in the upper part of walls. A chapter in the thesis is dedicated to some very well preserved case studies, which allowed a technical comparison. Particular attention is dedicated to Piazza Marconi site in Cremona, which is in course of editing.



2. Technique R_5 3d reconstruction



3. Piero di Puccio, Histories from Old Testament, Pisa Monumental Cemetery.



1. Rimini, surgeon's Domus, earth wall on brick footing.

CONSTRUCTION TECHNIQUES OF OTTOMAN BATH'S FROM 13TH TO 16TH CENTURY IN SEISMIC AREAS

Kerimcan Apak - Supervisor: **Giulio Mirabella Roberti**

Earthquakes have affected buildings structures since the beginning of construction history. The buildings that appeared to be strong in the usual life (like masonry or stone buildings) could be potentially devastate to a catastrophic level. Various interpretations have been forwarded about the potentials of the collapse of the buildings, based on observation of the response of the buildings during the earthquakes. Scientists work on the effects of seismic activity on the buildings, and on the prevention of major damages and loss of human lives. The outcomes of all these research's come through with the direction of building techniques and materials. Surprisingly the performances of historical buildings under the seismic activity can be very successful compared to contemporary buildings. The traditional techniques and earth materials performed successfully in past earthquakes. This issue took the scientist's attention to the historical building techniques. As well as the questions related to understanding these historical structures and their seismic behavior. For instance, many ancient structures in Turkey were still standing from centuries and passed many earthquakes without any consolidations. Therefore this issue have to be

investigated for giving a new light to the ancient construction details. There are so many questions that arise from the investigation on ancient structures. But one of the most interesting one is if the old masons were aware about the ancient anti - seismic constructions details or they used those techniques according to other criterions such as the patron's requests and the budget of the construction. This question is important in order to understand the development of the construction against the seismicity and the integrations of the construction details and architectural essences between different cultures, like appended in ancient Ottoman period. Ottoman baths are ones of the still standing structures from centuries without or with minimum consolidation. The typology of those buildings, their historical locations and cultural environment are very interesting and appropriate for investigation of this research topic. The cultural era, between 13th and 16th century in Ottoman domination, is the time where integration of construction details from the west and the east was achieved. The new society of the Turkish people and their innovative character formed a new architecture which was the source of classical Ottoman architecture. While the

development of the construction techniques and structural applications progressed in parallel to architectural styles. The essences of Byzantine, Seljuk's building techniques could be followed on the buildings of that era. In this study for understanding the anti – seismic construction awareness of the mason's in 13th and 16th centuries; research mainly focused on historical construction techniques in varied cultures in different of times such as Turkish seigniory, early Ottoman and Byzantine periods. Analyzing those techniques gave an overview of the history of construction and their integration with local cultures. And also some answers to the questions such as "how it was firstly built and developed". The secondly focused issue for finding an answer to the problem were analyzing the ancient masonries of the baths with techniques adopted for traditional buildings in seismic areas, such as masonry quality index evaluation, damage and collapse analysis. Those investigations were qualitative but also quantitative analyses which give an estimate of the strength of the masonries and possible collapsed scenarios. The outcomes from those investigations were the clues for understanding the usage of

preventive techniques for seismic protection. From the outcomes of the methodological investigations and comparison of historical outlines, it appears that the masons were aware of seismic activity and they adopted some ancient precaution techniques against the earthquake effects. However these techniques were used randomly in building scale facing other constraints such as budget and patron tendency in architecture. As well those preventive techniques were not commonly used in city scale. Some architectural, construction tendencies and integrations were commonly used in settlements however they not became generalized. The results and the research methods of the thesis are giving a perspective of thoughts of construction of ancient buildings that we can learn some ideals about their resistance to the seismic activities.



1. 15th century historical structure (Ismail Bey Bath) in Iznik-Turkey.



2. 15th century historical structure (Ismail Bey Bath) in Iznik-Turkey. Timber tie beam holes were located inside the walls of the structure. Timber tie beams were kept together the masonry walls for the horizontal loads.



3. 15th century historical structure (GaziMihalBey Bath, 1421 A.D.) in Edirne-Turkey. The corners of the building constructed with materials more durable, which was done in purpose for keeping the structure more stable for horizontal loads. On the upper photograph, strengthened corner of the building was seen. On the lower photograph, collapsed corner was seen.



4. 15th century historical structure (GaziMihalBey Bath, 1421 A.D.) in Edirne-Turkey. The timber tie beam holes were inside of the masonry structure. As well the brick knitting patterns were behave like a horizontal beam around the perimeter of the structure against the horizontal loads.

THE TRANSMISSION AND CIRCULATION OF PRACTICAL KNOWLEDGE ON ART AND ARCHITECTURE IN THE MIDDLE AGES. THE CASE OF COMPOSITIONES LUCENSES TRADITION AND ITS CONNECTION TO VITRUVIUS' DE ARCHITECTURA

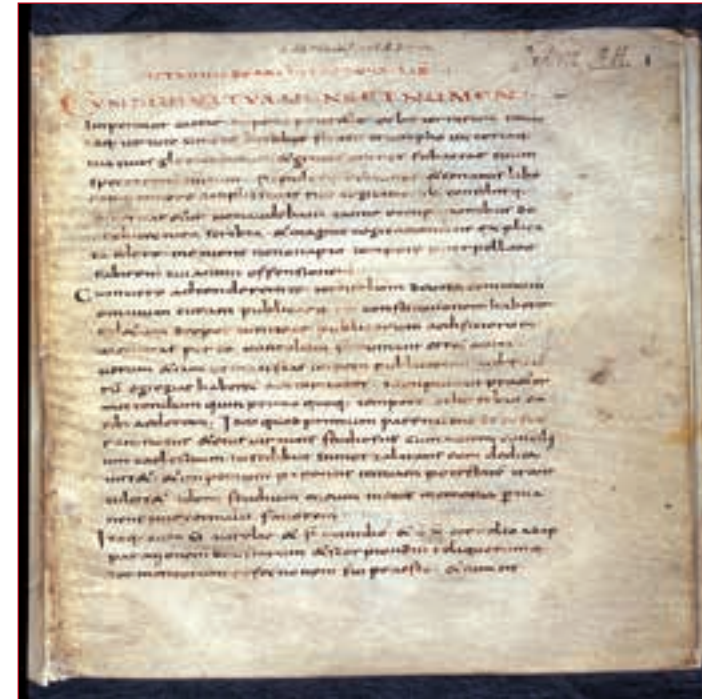
Giulia Brun - Supervisor: Prof. Alberto Grimoldi

The transformation of literary culture of the past into reliable documents for a history of artistic and building knowledge may be complex and time-consuming. Yet the keen interest medieval art and architectural studies have been devoted to texts from the past has not yet entailed a thorough reflection on some crucial factors that may tell us important indications on the influence of those compilations. This dissertation copes with the earliest Western example of a recipe book for practical arts known as *Compositiones lucenses* that includes 160 texts, in Latin, for the making of art products, decorative motifs, and architectural elements. This study attempts to reassess the issue conferring a new perspective on the circulation of *Compositiones lucenses* and its practical knowledge by means of new evidence and different courses of research. I argue that *Compositiones lucenses* offers far more than just a small group of medieval manuscripts; it should be seen as a recipe book with an incredible diffusion in the Middle ages, which benefits of the extraordinary connection with Vitruvius' *De architectura* that is the most important work on practical arts and architecture from the Antiquity. Eventually, I endeavour to open the way for a different interpretation on the meaning and influence of

practical arts treatises during the Middle Ages, on the basis of a new reading of *Compositiones lucenses* and its tradition, of its medieval manuscripts and of a particular version that was systematically copied with Vitruvius. Despite the centuries of studies and the innumerable critical editions on its first manuscript Lucca, Biblioteca Capitolare, 490 (8th century), many crucial factors on the real influence of *Compositiones lucenses* during the Middle ages have been in turn neglected or overrated. Much of the literature debate is constantly revolving around only few segments of the problem, among which the identification of *Compositiones lucenses* with another collection, of an alchemical character, known as *Mappae clavicula*, stands out. On the contrary, there has not been enough research on the amount of manuscripts that copied the recipe book and its true contents. New evidence suggests that at least twenty-six manuscripts transmit *Compositiones lucenses*, much more than it was initially thought. Moreover, the data that I gathered points out that in several Vitruvian manuscripts may be found another version of *Compositiones lucenses*, autonomously created, that I termed *Editio minor*, on which it was urgently necessary a

thorough exploration.

The dissertation is divided into two parts. The first one deals directly with the complex issue of *Compositiones lucenses* tradition. It follows the history of the recipe book from its first medieval specimen as a collection that developed heterogeneously even beyond the Middle Ages. Much of this section centres on the data given by the manuscripts, which have been systematised and rationalised to provide new objective elements for understanding how the transmission took place. I imply the rigorous framework of codicology to posit medieval manuscripts of *Compositiones lucenses* tradition as crucial factors for the circulation of practical knowledge on art and architecture. For the first time, twenty-six manuscripts of the recipe book have been thoroughly examined both in their general contents and in their codicological features. A closer look at the data indicates the capacity of *Compositiones lucenses* of being continuously subject to additions, subtractions and reformulations so that its historical development may be followed from Lucca manuscript to the later tradition, resulting in at least seven different phases. The discussion then centres on three remarkable examples of recipes for mortars and plasters



1. Marcus Vitruvius Pollio, *De architectura* London, British Library, ms. Harley 2767, f. 1r (8th-9th century)

making given by *Compositiones lucenses* tradition that provide confirmatory evidence about a multifaceted transmission of the collection. On the basis of new data, it seems also fair to suggest that the nucleus of recipes that I named *Editio minor* has been copied systematically only after Vitruvius' *De architectura*, from the very first known specimen London, British Library, ms. Harley 2767 (Fig. 1) to at least the 15th Century. The second part, on the contrary, is focused on the distinctive connection of *Editio minor* with Vitruvius' *De architectura*. This section borrows tools and notions from philology, linguistics and historical pragmatics that I adapted to the present aims. On these grounds, I reconstructed

the text of *Editio minor* in a critical edition portrayed in a *stemma codicum* in which two families have been isolated, with a third branch outliving between the lines of an unpublished 15th century manuscript. The analysis confirms the claim that *Editio minor* is an ancient selection borrowed from an existing wider tradition, rather than a first example in an archaic phase of that recipe book later subject to severe additions and textual agglomerations. Moreover, I develop another innovative method that codifies the twenty-six texts of *Editio minor* in a sequence of strings representing the instructions as displayed in manuscripts. By employing this method, it is now objectively possible to establish whether a given text

can be truly considered as a recipe by satisfying a certain number of questions and verify the quantity of "implicit knowledge" inside each procedure. Eventually, I apply the concept of "text-colony" –i.e. a text that, like a beehive, does not owe its survival on its units– to verify that *Editio minor* is above all a textual structure in which agglutinations and estrangements of its single units do not undermine its meaning and utility as a practical arts recipe book. This approach aimed to rationalise in an inter-subjective way the typical capacity of this medieval literary genre of recipe books of attracting upon its nucleus other texts thematically related. In short, this dissertation contributes to broaden our horizons on the actual presence of this literature in medieval Europe by assessing the diffusion of written records on art and architecture. It provides convincing outcomes to prepare the ground for a future comparison between the availability of those texts and the material marks in coeval artefacts and built environments.

THE PINACOTECA AMBROSIANA THROUGHOUT THE 20TH CENTURY: REFURBISHMENTS BETWEEN MUSEOLOGY AND MUSEOGRAPHY

Silvia Colombo - Supervisor: **Prof. Pietro C. Marani**

During the 20th century the Milanese Pinacoteca Ambrosiana goes towards significant changes, here analysed and investigated from a wide perspective. The span of time considered starts with the first setting of the century (1905-1907), promoted by Prefetto Achille Ratti, and ends after the Second World War, when architect Luigi Caccia Dominioni was called by the museum administration to refurbish the museum (1959-1966). In this context – introduced by a general dissertation on the Milanese museums at the end of the 19th century and concluded by an overlook on the most recent events of the Pinacoteca – more attention will be given to the changes occurred to the museum during the “ventennio fascista” (more precisely between 1927 and 1939). To fully understand the historical path accomplished by the museum throughout a century, an interdisciplinary approach, between the humanities and the social sciences, is essential: actually museum studies, history of art, restoration and architecture from one side and memory studies on the other are used as useful instruments to read the exhibition space through the decades. In this way, and also thanks to a comparative consultation of bibliographic and archival

sources, it is possible to follow out the architectural, artistic and collecting aspects characterising every single construction site and to understand the reasons behind every renovation project too. Going through the complex series of the Pinacoteca Ambrosiana renovations and, at the same time, looking at the coeval situation, national and international, this research aims to give the Milanese museum a context that we can define both “historical-cultural” and “topographic”. Moreover, with the help of the social sciences, it tries to explain some choices that made the Pinacoteca a unique case in Milan, but also marked its critical fortune in some historical periods. Finally, trying to put together all the traces left by the museum from time to time, this research intends to identify – as much as possible – a recognisable identity of the museum, survived over against the challenges offered by a crucial period like the 20th century. The thesis is composed by seven chapters which highlight some significant topics related to the Pinacoteca Ambrosiana and also follow a chronological path. The first chapter – the only one exclusively based on published material – is a short dissertation on the history of the museum, since its opening, in

the 17th century, until the end of the 19th century; of particular interest, here, are some literary milestones such as the *Musaeum* (1625) by Federico Borromeo and the Pinacoteca Ambrosiana guide wrote by the architect Luca Beltrami (1895), able to show the spatial changes occurred to the museum during the decades. The second part draws attention to two different museum settings: the one committed by the Ambrosiana administration to the architect Luca Beltrami, the art critic Gustavo Frizzoni, the restorer Luigi Cavenaghi, and conducted between 1905 and 1907; the other carried out between 1921 and 1923 by the architect Ambrogio Annoni, called by the new Prefetto, Luigi Gramatica, to design a new arrangement of the institution (Library and Museum) after the difficult moment of the First World War. The third part, which is the “load-bearing structure” of the thesis, examines the cultural situation of the Pinacoteca Ambrosiana between the Twenties and the Thirties, during the “ventennio fascista” and until the Second World War. In this moment the museum, enlarged thanks to the new spaces acquired from some properties related to the San Sepolcro church, is going to deal with a huge change.

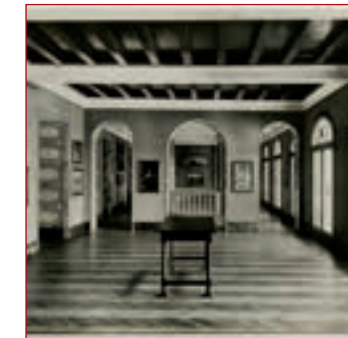
The whole project, desired by Prefetto Giovanni Galbiati, is successfully completed in two different rounds (1927-1932 and 1936-1938) thanks to an *équipe* of professionals composed by three architects coming from Politecnico di Milano – Gaetano Moretti, Ambrogio Annoni e Alessandro Minali –, artists and artisans. The result, a gallery nostalgically looking at the past, is thus contextualised through a series of national (“Mostra della Rivoluzione Fascista”, the opening of the Pinacoteca Vaticana, both in 1932, and the Milanese “Mostra di Leonardo”, in 1939) and international examples (*Muséographie* conference, organised in Madrid in 1934).

The following chapter, contextualising the lapse of time between the anglo-american bombings (1943) and the Milanese Reconstruction, highlights the peculiar situation of the Pinacoteca Ambrosiana, especially if compared to other similar cases. The museum, actually, rebuilt exactly like it was just before the war, stays strongly linked to its past due to an obstinate decision taken by Galbiati himself, who – furthermore – would be pushed to resign in a few years (1951). Finally, the late intervention of the architect Caccia Dominioni (1959-1966), examined in chapter 5, is able to imprint on the museum a huge change but, on the other side, it excludes the “Galbiati rooms”, added during the Twenties. In this way, the gradual oblivion that occupies the rooms, closed and then reused as storages for the art collection, is thus considered from the point of view of the memory studies, able to link

the architectural space to its historical past – in this case directly connected to the military and political trauma of the previous period.

Chapter 6, considering the events occurred to the Pinacoteca during the last decades until the “Grande Ambrosiana” project (1990-1997), capable of recover the forgotten spaces of the museum, tries to follow the identity of an exhibition space that, at the end of the century, is the result of a “collection” of refurbishments.

In closing, the seventh section collects the most significant documents examined in some public and private archives spread between Milan and Rome.



1. Pinacoteca Ambrosiana, “Sala dei moderni”. Setting commissioned by Giovanni Galbiati to the architects Moretti, Annoni, Minali (1927-1932) – courtesy Archivio Storico Intesa Sanpaolo, Milano



2. Pinacoteca Ambrosiana, “Leonardi Aula”. Setting commissioned by Giovanni Galbiati to the architect Ambrogio Annoni (1936-1938) – courtesy Archivio Storico Intesa Sanpaolo, Milano



3. Pinacoteca Ambrosiana, Sala di Nicolò da Bologna (1996). This room was closed after the intervention of the architect Luigi Caccia Dominioni (1959-1966) and reopened during the Nineties – courtesy Archivio Storico Intesa Sanpaolo, Milano

ARTURO DANUSSO IN EARTHQUAKE ENGINEERING AND SKYSCRAPER DESIGN

Valentina Sumini - Supervisor: **Prof. Claudio Chesi** [Politecnico di Milano]

Co-advisors: **Prof. Jamshid Mohammadi** [Illinois Institute of Technology]

Prof. Luigi Sorrentino [Università La Sapienza]

The idea of this research was originated by an important question that was raised related to the preservation of reinforced concrete skyscrapers built in the fifties and sixties of the 20th Century. The question was: "Are skyscrapers built in era of fifties and sixties still confirm with the provisions of the new structural design codes practiced today?" The adequacy of these structures is an important piece of information; since this information will identify specific design factors that are prevalent today and were not considered when older versions of codes were used.

The change in the code and introduction of new factors into the design process resulted in a radical decision regarding many buildings at the end of the 20th century; and that decision was in favor of demolition.

The research proposed herein intends to analyze the structural performance of some iconic reinforced concrete tall buildings in relation to the current design code requirements - both in Italy and in the United States. This research is performed by examining the work of one of the renowned engineering scientists of the Twentieth Century: Arturo Danusso. Arturo Danusso has been responsible for a significant

contribution to the use of dynamics in the design of earthquake-resistant structures especially after the Southern Calabria-Messina Earthquake of 1908. His most important papers were focused on the problem of designing houses that would survive during earthquakes without the danger of collapse. Danusso was probably the first to (1) propose a dynamic approach to design as opposed to the static lateral force method; and (2) apply the modal analysis technique in structural design. Moreover, he proved scientifically that the seismic demand on structures does not depend upon the ground motion characteristic alone. He also showed skills in mathematics in solving differential equations and linear systems.

In this research, a mathematical model of his project for a seismic resistant house is presented to better explain his intuitions in seismic engineering. From the studies in earthquake engineering, Danusso acquired the knowledge for another important contribution to civil engineering; and that is the design of skyscrapers in the fifties. Reviewing his papers related to dynamics, it is possible to demonstrate the connection between seismic design and high rise building conceptual

design and behavior. This is clearly shown by his studies on the mechanical vibration of structures, which were published in three main journals (*Il Cemento*, *Il Monitore Tecnico* and *Il Giornale dei Lavori Pubblici e delle Strade Ferrate*) between 1909 and 1954 and in as some chapters in different books. He had perfectly understood the importance of the dynamic behavior of structures, not only in relation to seismic actions but also with reference to tall-buildings designs. It is important to note that the most challenging force action on high-rise buildings is wind, and not ground shaking. The importance of his contribution can also be understood based on his strong belief in the role of experimental testing for full understanding of the dynamic response of structures. His book on experimental methods took advantage of the shaking table at ISMES in Bergamo, through which scaled models could be tested.

Danusso was also involved in the structural analysis of the main high-rise buildings in Milan in the fifties, such as the Breda Tower, the Velasca Tower and the Pirelli Building. The design of these skyscrapers exhibits different structural solutions,

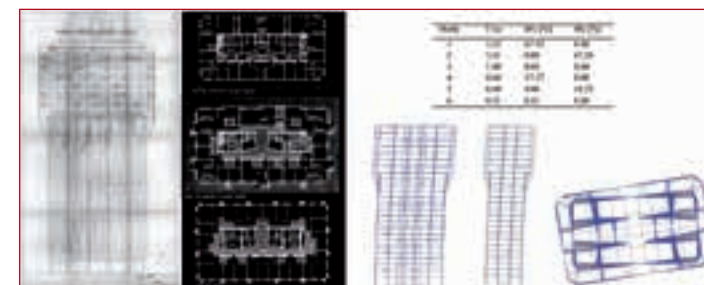
namely, the shear wall and rigid frame systems, the tube and tubular system with a rigid core and the gravity system. In this thesis, a critical overview of the architectural design process has also been pointed out in an attempt to highlight the connections between the architectural form and the structural design of these skyscrapers. Gio Ponti and Pier Luigi Nervi in the Pirelli Building, BBPR in the Velasca Tower and Luigi Mattioni in the Breda Tower worked in very close cooperation with Danusso in designing buildings that exhibit the monolithic sculptural nature of concrete, while exploring new structural layouts for each one. This kind of study can go beyond the Italian experience. And as such, a comparative analysis has been developed with the Astor Tower and Marina City Towers, which were designed and built in Chicago, around the same period. They both were in concrete and presented the same kind of structural design. In particular, the Twin Marina City Towers were the tallest residential reinforced concrete skyscrapers in the world in the sixties.

The choice of thoroughly evaluating the structural performance of the Marina City Towers is strictly related to the analysis of the main characteristics of Danusso high-rise buildings design. These characteristics are: (1) an iconic architecture, (2) the use of reinforced concrete, (3) the challenge of height, and (4) the introduction of a core as the main shear system to resist the lateral loads (as is the case in the Velasca Tower).

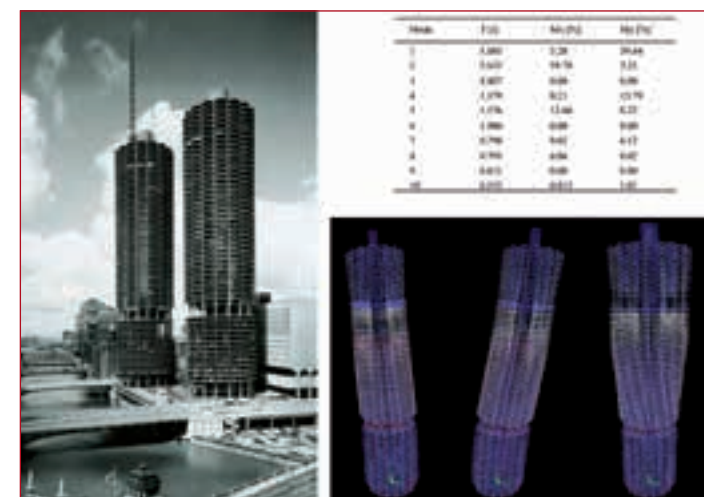
Moreover, it is noted that the

architect of the Marina City Towers, Bertrand Goldberg, was certainly influenced by the Italian skyscrapers having access, in his personal library, to all the articles related to the Italian high-rise buildings (he had subscriptions to *Casabella*, *Domus*, *L'Architecture d'Aujourd'hui* and other periodicals). Therefore, the widely-discussed and advertised Velasca Tower, from an intellectual point of view, was completely known by Bertrand Goldberg, who was both an architect and an engineer. With this dual expertise, he was able to understand the innovative core system introduced by Danusso.

Concluding, all the performed structural analyses of the skyscrapers mentioned above have shown high capacity resources and very effective behavior characteristics. These buildings were conceived with a strong initial cooperation between architects and structural engineers, with neither appearing to prevail and both intending to build a significant and durable work for their respective competence. Their innovations are still recognizable nowadays and confirm the need of the synergic collaboration between architects and engineers in the design and construction process.



1. Left: Original drawings of the Velasca tower (1956-58). Right: Synthetic results of the modal analysis obtained by the FEM model built for the present work.



2. Left: Marina City towers (1959-62). Right: modal analysis.

EARTHQUAKE RESISTANT SYSTEMS: EXPERIENCE BASED CONSTRUCTION TECHNIQUES IN VERNACULAR ARCHITECTURE. TWO STUDY CASES: THE VILLAGE OF CASTELVECCHIO CALVISIO (L'AQUILA, ITALY) AND THE TOWN OF LEFKADA (LEFKADA ISLAND, GREECE)

Sandra Tonna - Supervisor: **Prof. Claudio Chesi**

In the thesis the issue of seismic protection structural solutions is debated, with reference to the criteria which were developed within the constructive tradition before earthquake resistant design started to be developed as a science. The scientific approach to design dates back to the beginning of the '900; being based on the interpretation of both the physical phenomenon of ground shaking and of the structural response, it opened to the possibility of quantitative design evaluations.

The research is addressed, in particular, to the subject of residential architecture, which is examined in the special context of a "poor" architecture in "critical" areas. "Poor" refers to situations where, due to economic reasons, the use of both local resources and experience coming from empirical traditions has no alternatives; as to "criticality", reference is made to the case of specially severe environmental conditions, in relation to which a stronger need to provide adequate safety to buildings is felt.

In the pre-modern age, before scientific computational procedures were formulated, effective earthquake-proof structural solutions were developed following rules simply based on "common sense" and experience. This kind of

knowledge, handed down from generation to generation, led to the definition of structural solutions suitable to resist a variety of critical environmental situations.

In this way, both the original morphology and the evolution in time of most effective construction techniques are directly related to the level of criticality of local actions: in areas affected by severe and frequent natural disasters, special systems had to be developed. In order for this to happen, it is necessary that the memory of the natural event and the knowledge of the damage are not lost. The risk consciousness induces local society not to forget nor abandon traditional construction techniques, but rather to maintain and improve them. In this context, the thesis aims to develop an extensive description of the seismic protection elements developed in the building tradition; this kind of knowledge provides the basis for the subsequent evaluation of their real effectiveness through the use of modern structural analysis tools. In this spirit, a simplified evaluation of the resistance levels is developed in the thesis, based on a simple, yet standard, numerical procedure.

The theme was initially examined with reference to the case of

the Apennine villages in the province of L'Aquila, for which, after the 2009 earthquake extensive campaigns for damage description were performed. The analysis of the building framework and of the seismic protection elements which are typical of these villages is based on the results of a detailed survey work carried out on the field, supplemented by the study of local economical and historical conditions; specifically, historical earthquakes and the subsequent reconstruction and reinforcement interventions have been examined (Fig.1).

The study was focused on the area of Castelvecchio Calvisio, which provides a faithful image of ancient building traditions. After performing the identification and description of the seismic protection elements, the simplified quantitative evaluation was applied to an estimate of the available seismic resistance. This has suggested an interpretation, in terms of specific numerical values, of the safety resources implicit in the construction systems developed by tradition.

In order to go deeper into the debate about the effectiveness of building traditions developed on empirical bases, the analysis has been extended to a second case, different in its peculiarity, yet similar to the first example as belonging to the Mediterranean

environment and, specifically, to a critical area, subject to frequently recurring major earthquakes and characterized by a well defined traditional building system.

The interest was focused on the Ionian island of Lefkada, where critical environmental conditions include also soil related problems, due to the original presence of a marshland, subject over the time to reclaiming works. Seismic and geotechnical criticalities have significantly influenced both the structural response and the adoption of a suitable foundation system. The availability of abundant historical documentation on the local tradition has allowed an interesting interpretation of the building system, which was developed as a response to repeated earthquake experience.

As in the previous study case, the problem has been analyzed under a general perspective, including historical and economic conditions typical of the area: the island historical seismicity has been studied and important information have been drawn from the analysis of unpublished archival documents activities which followed historical earthquakes.

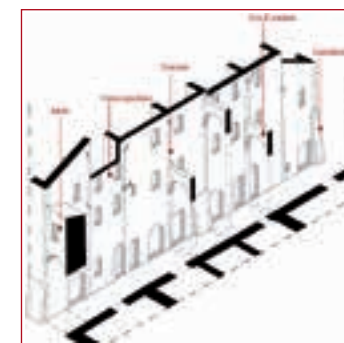
In particular, an interpretation of the foundation systems developed by tradition is

proposed. Also in this case, finally, the simple numerical evaluation has been performed in order to explain the surprising ability of builders to develop, in the past, a construction technique able to oppose strong seismic effects (Fig.2).

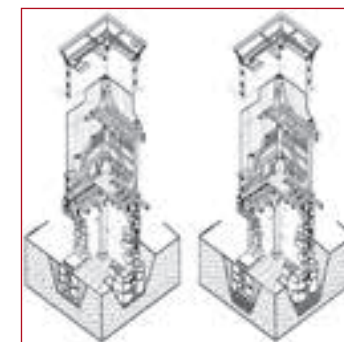
The two selected study cases also allow to discuss the implications of the earthquake return period on the building quality: Castelvecchio Calvisio and Lefkada are both characterized by high seismic hazard but with different return periods: 200 and 30 years, respectively. This has led, in the first case, to alternately forget and rediscover the tradition and, in the Greek one, to the development of a structural system able to resist simultaneously two different criticalities, the geotechnical and the seismic one.

As a general conclusion, the research program and the field investigations provide documentation on the constant effort of builders, in the past, to conceive seismic resistant structures. In both the cases of Castelvecchio Calvisio and Lefkada this effort has resulted into resistance levels of the masonry structures basically in line with the design requirements in force today. Collecting local construction techniques and maintenance procedures is the basis for

defining "land archives", capable of suggesting new knowledge horizons and also of providing methodological guidance on intervention methods for the conservation and enhancement of the historical building stock.



1. Sketch of recurring seismic protection elements and their arrangement in a building aggregate



2. The traditional system construction of Lefkada, with particular reference to the two different foundation structures present: on the left foundation wall with pozzolana in the mortar, on the right with the timber grid.

THE ENCAUSTIC PAINTING BETWEEN REVIVAL AND INVENTION. THE DEBATE IN THE TECHNICAL LITERATURE AND THE FIRST APPLICATIONS ON PLASTER IN MANTUA, VERONA AND CREMONA BETWEEN THE 18TH AND 19TH CENTURY

Paola Travaglio - Supervisor: Prof. Alberto Grimoldi

The research focuses on one of the most debated painting techniques – the encaustic painting – arisen in the ancient times and rediscovered in the second half of the 18th century. The study aims to better understand what encaustic painting is from a technical point of view and to propose an overview of the debate on this technique, verifying, through the compared study of bibliographical and documentary sources, its origin, the reasons, the different contexts, the material outcomes. Essential moment of the artistic culture born from the Enlightenment, the debate on encaustic painting mainly took place between the pages of treatises by scholars and artists. For this reason, the starting point of the research is the wide technical literature which deals with encaustic painting from the antiquity to the 19th century. After a review of the classical literature, which will be the basis of the following experiments, the discussion proceeds with an analysis of the technical literature between the Middle Ages and the end of the 17th century, in order to detect if and to what extent it had carried on handing down memory of this technique. The central part of the research finally consists in the 18th and 19th century debate on encaustic painting, with the

study of the French, English, Spanish, German, and especially Italian technical literature. If almost all the eighteenth-century literary works were based on the interpretation of the obscure words of the Latin authors, aiming at the *revival* of what was considered the most widespread ancient painting technique, the experimentations also gave rise to the *invention* of new pictorial procedures. In the 19th century there was a partial change of perspective towards encaustic painting, whose research, particularly in Italy, intertwined the debate on the use of varnishes in painting, the first chemical analyses on archaeological finds, and, above all, the events related to the conservation of artworks, finding then application also in the industry, where 'encaustic' became synonymous with products containing wax designed to protect various materials. Some notes on encaustic painting in the Italian manuals on painting techniques of the first half of the 20th century conclude the chapter. The second part of the research aims to deepen the root of the Italian debate on encaustic painting, with particular attention to the first applications of this technique on plaster in the cities of Mantua, Verona, and Cremona. The study is

based on the consultation of bibliographical-, periodical- and archival-sources, mostly presented in the documentary appendix. The first section focuses on the spread of the first Italian publication on the topic, the *Saggi* by the Spanish ex-Jesuit Vincenzo Requeno, retracing the events relating to the two editions (1784 and 1787) and highlighting how the main centers of diffusion of encaustic painting, at least in the first phase immediately following the publication of the text, were found in Northern Italy, anticipating – albeit slightly – the most known executions carried out in Rome. The second section investigates the spread of encaustic painting in Mantua, city which promptly embraced the methods proposed by Requeno thanks to the work of painters and decorators who worked in some of the most important decorative works in Mantua in the last two decades of the century. Some of them took part in a kind of 'encaustic painting academy', set up by the Marquis Giuseppe Bianchi in his palace. It is therefore proposed a first analysis of this contest, with particular attention to the figure of the Spanish ex-Jesuit Juan Andrés, who played a crucial role in the spread of interest for encaustic painting in Lombardy.

The city of Verona saw instead an intense debate on the preparation of Punic wax, which resulted in the publication of several dissertations, starting from the one by Anton Maria Lorgna. His research on encaustic painting is mainly reconstructed through his correspondence, together with the events related to the award for the painting 'in Punic wax and encaustic' established at the Academy of Painting in Verona, and the encaustic decorations performed in the city. A more in-depth analysis is then dedicated to Cremona, the city which saw the update on the Italian and European technical literature, and also the presence of clients, intellectuals, and artists who, thanks to their network of relationships and antiquarian interests, promoted the spread of encaustic painting, especially on plaster. Besides the early interest in this technique shown by Giambattista Biffi, whose unpublished writings of artistic and antiquarian nature are investigated, the research focuses on the abbot Isidoro Bianchi, the real protagonist of the Cremonese debate on encaustic painting, and the Spanish ex-Jesuit Ramón Ximénez. Even in this case their figures and the role played in the spread of encaustic painting in Cremona are investigated through their extensive correspondence and writings, published and unpublished. The supposed encaustic paintings made in Cremona in the 18th and 19th centuries are then retraced, focusing on the works by Santo Legnani, Luigi Benini, Francesco Ferrari, Giovanni, Giuliano e Giulio

Motta, Gallo Gallina, who worked in some of the most important noble residences of the city. The comparison with some unpublished documents has also allowed to better clarify some attributions and the history of the decorative interventions.

The third part of the thesis presents the results of some early research of experimental nature.

The first section deals with an attempt of classification of 'the encaustic painting techniques', made on the basis of the technical literature. One of the main question related to 'encaustic' concerns the terminology. In fact, this *lemma* – even in relation to its etymology – has been used over time to indicate various art techniques and materials: from inks for writing to different procedures of wax painting, from enameling to the encaustication of paintings and the finishing of artifacts and sculptures.

The classification is then followed by a review of the main scientific studies dedicated to the investigation of waxes as pictorial materials, with the aim of underlining the achievements of the scientific disciplines applied to the conservation field about encaustic painting and the analytical techniques used in the investigations.

The third section of the chapter deals with the making of samples of encaustic painting on plaster, prepared according to the recipes of the technical literature, some of which were later examined with FT-IR, in order to check the effective reproducibility of the procedures and to test the response of

the analytical technique in the identification of wax in complex mixtures. At the end of the research the results of the scientific investigations made on some of the mural paintings by Gallo Gallina in Palazzo Ala Ponzzone in Cremona are presented.



1. Luigi Benini, *Hebe and the Eagle of Jupiter*, 1795-1801, encaustic painting (?), Cremona, palazzo Cattaneo

THE DUCAL PALACE IN MANTUA. THE ARCHITECTURAL METAMORPHOSIS OF THE PALACE INTO A MUSEUM (1887-1938)

Lisa Valli - Thesis supervisor: **Paolo Carpeggiani** - Co-supervisor: **Alberto Grimoldi**

The research focuses on the Ducal Palace of Mantua and, in particular, on its architectural metamorphosis into a museum (1887-1938). The aim of my study is to provide a concise critical analysis of the Palace in its final remarkable transformation from an administrative seat into the museum we know today. Contextually, I have taken into account the people and the craftsmen involved in the works of renovation and restoration and the maintenance procedures during such a process. The main hypothesis behind my research considers the Palace as an architectural organism which is both unique in its size and complex stratification, and, simultaneously, it is analogous to other great historical and architectural complexes typical of the region, due to their similar possibilities of conservation and fruition.

What I wanted to argue through such a concise critical analysis is that the 'fortune' that the Palace has enjoyed while facing its transformation into a Museum and the subsequent preservation did not cause divestiture and abandonment but it is rather to be interpreted as an interaction of political, social and cultural instances. Such an interaction can still be highly enlightening for the future management, and therefore the future

conservation, of the National Heritage and, more specifically, of the Ducal Palace in Mantua. After a first phase of the research devoted to the analysis of the main published resources, the research on the documentary sources were therefore undertaken at the archives of those institutions and people historically involved in the administration and preservation of the Palace. In many cases, the analysis of the sources was necessarily preceded by an extensive survey and the compiling of topographical instruments for the consultation of the archival records. The next step was the drafting of the texts by comparing the architectural artefact and the information found in bibliographic and documentary sources.

The first part of the thesis offers a critical synthesis of the findings of the research: I have been able to mark four main phases of the transformation process of the Gonzaga court in a State Museum. A first phase took place between 1707 and 1866. I have taken into account the most significant events in order to outline the characteristics of the Palace at the end of the process of gradual disposal of the Court of Mantua from being a representative core of the power of the Gonzaga Duchy to its becoming the administrative

headquarters of an increasingly peripheral province of the Austrian governorate. A second stage can be identified with the two decades following the Annexation of the Province of Mantua to the Italian Kingdom (1866), which ended with the takeover of the Palace by the Ministry of Education (1887). The Court, registered among the buildings forming the Estate Endowment of the Crown (1868), became a legacy of a Nation to be built, in which such a legacy, at least initially, did not have a clear role. This phase also witnessed the progressive recognition of the "monumental value" of the Palace: the first interventions, marked by a mainly conservative character and performed by state initiative, were manifestations of this process.

Following the Ministry of Education taking charge of the Palace, the first vicissitudes of the Palace as a monumental site regularly open to the public began (in October 1887). As a result, the first major interventions took place on the initiative of the appropriate Regional Office for the Conservation of Monuments. The interventions, made possible mainly through the contribution of the local authorities, were partially carried out as a step of the process of urban transformation and

isolation of the monument and, partly, to ensure its preservation and accessibility. Once again, the monumental complex had to find a new function: the Museum, wonderful but lost since 1627, became a Museum-pretext through an *inventio*, justifying the acceptance of the architectural complex, and as a symbol of the pre-unification past of Mantua. The conception of the museum is outlined through the analysis of the progressive stages of the rediscovery of the vocation of the Palace as an exhibition venue and the drawing up of the Convention between the State and the Mantua institutions for the transport of the civic collections in the Palace (1915), up to the concrete design of the spaces and the location of the museum (1921).

In the first post-war period, the conditions required for the construction of the project of the Museum were ready. The finding of the resources needed for the affordability of the initiative of the Museum was closely related to the immediate and pervasive adherence to Fascism that was manifest in Mantua and that ensured, both directly and indirectly, the government support. The architectural interventions needed to transform the palace into a museum mainly took place between 1923 and 1938. The Museum was presented for the first time in its entire configuration on the occasion of the Iconographic Exhibition of the Gonzagas (1937). While the majority of the great Italian museums was established after the Second World War, the Museum of the Ducal Palace in Mantua was made almost

twenty years earlier, by 1938. However, some interventions that occurred in the 60s must be remembered as necessary premises to the comparison with the architecture of the Palace today, such as those mainly aimed to refit the museum and to recover its decorative wall paintings cycles. The Palace Museum thus began its adventure as a repository of civic collections and museums, and eventually, in the second quarter of the twentieth century, it firstly became a claimed Museum, demanded both by the citizenship and by the State which, through this, tried to build their image, and finally it has aligned to the Italian State Museums, in the vicissitudes and purposes, as well as in the lack of resources and yet in its excellence.

In the second part of the thesis, made up of the Tools, of the Workbook and the Equipments, I have presented both the findings concerned with the individual portions of the building (data which may support the knowledge and preservation of the complex), and the working tools built for the drafting of the study and for the future promotion of the immediate access to the knowledge resources available on the Palace.

The main outcome of the research consists in the reconstruction of the 'image' of an architectural complex absolutely outstanding in its stratification and sedimentation, in which the reality and the concreteness of its buildings, as well as the magnitude of the efforts made for its defense and for its knowledge, far outweigh the transitional historical and

institutional impasses that, obliquely, have caused its wounds. The image will be more faithful, and so expendable in conservation activities, the more it will be possible to further deepen the research and the comparison with the artifact itself.



1. The Ducal Palace in Mantua antecedently to the earthquake of spring 2012 (March 2012).