

MECHANICAL ENGINEERING | PHYSICS |
PRESERVATION OF THE ARCHITECTURAL
HERITAGE | SPATIAL PLANNING AND URBAN
DEVELOPMENT | STRUCTURAL SEISMIC AND
GEOTECHNICAL ENGINEERING | TECHNOLOGY
AND DESIGN FOR ENVIRONMENT AND BUILDING
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AEROSPACE ENGINEERING | ARCHITECTURAL AND
URBAN DESIGN | ARCHITECTURAL COMPOSITION |
ARCHITECTURE, URBAN DESIGN, CONSERVATION
OF HOUSING AND LANDSCAPE | BIOENGINEERING
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| MATERIALS ENGINEERING | MATHEMATICAL
MODELS AND METHODS IN ENGINEERING



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 (Università IUAV, Venezia; Università di Genova; Università di Brescia; Università degli Studi di Bergamo; Istituto Superiore per il Restauro e la Conservazione ISCR; ICVBC - CNR, Milano); 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 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. The relationship with Italian Ministero per i beni e le attività culturali e il turismo - Mibact, that will certainly increase in the next few years, 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. In the last years: within the International UNESCO chair the Summer School of the PhD School HERITAGE AND DESIGN *Architectural Preservation, Design and Planning in World Heritage Cities and Landscapes*; organized from the co-operation with other PhD programmes in the Politecnico di Milano, the Course of the PhD School 150th Anniversary of the Politecnico di Milano, 1863 - 2013 - *Tradition and Perspectives of Polytechnic Culture in Europe*.

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.

Within this plan, different experiences are organized in order to get PhD candidates in touch with study and research developed in Italian and International context: lately the visit to important building site, such as the Colosseo in Rome (Istituto Superiore per il Restauro e la Conservazione ISCR, formerly Istituto Centrale del Restauro) or the Sanctuary of Vicoforte in Cuneo (Mario Chiorino, Emeritus professor - Politecnico di Torino); moreover the visit to the underwater archaeological site in Baia (Napoli) in

relation to the ISCR project "Restoring Underwater". 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.

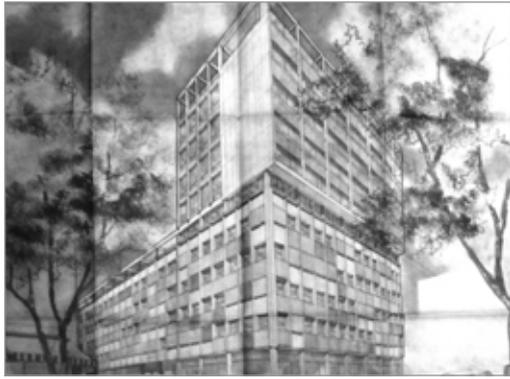
Research organization and topics

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



1. Selinunte (Sicily), Temple E, detail of a colonnade reassembled between 1956-1959 with the aid of reinforced concrete under the direction of archaeologist Iole Bovio Marconi.



2. L. Mattioni, Design for the apartment and office building in via Rosellini (Milan), 1959 (Luigi Mattioni Archive).

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 applied to historic buildings tradition, as the ones related to the archaeological sites also analyzing the behaviour and durability of “mixed structures”, as the research focused on the 20th c. restoration on the Temple of Pythian Apollo at the Acropolis of Rhodes **fig. 1**); or to twentieth-century heritage, as the thesis concerning Luigi Mattioni architect’s career and production (1934-1961), with a special attention to the subject of high-rises in Milan **fig. 2**); or to critical and historical investigation on specific construction technology, as the research which deals with the Vittorio Emanuele II Gallery, the construction of its 19th c. iron-glass cover and the interventions from the completion of the construction works until today **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 rural building techniques in central Po valley between 4th and 14th century); at the same time it features innovative, pioneering themes: research about the energy response of buildings targeted to the reuse of existing technical systems and to reducing the impact of new systems which, since long, have been



3. View towards the dome of the iron-glass roof of Gallery Vittorio Emanuele II as it is today.

extensively addressed by the PhD programme and at the heart of an International exchange with European universities and research labs; 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). The research linked to the analysis of aggregate building’s seismic vulnerability, developed in the case study of Civita di Bagnoregio, deals with this specific topic **fig. 4**).



4. View of Civita di Bagnoregio from the San Francesco overlook (G. Campanini, 2014).

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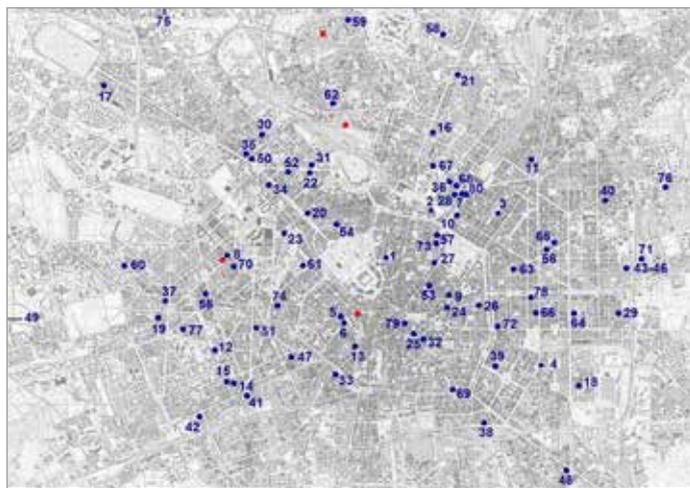
LUIGI MATTIONI THE ARCHITECT. FROM POLYTECHNIC EDUCATION TO PROFESSIONAL ACTIVITY, 1934-1961

Giorgio Calegari – Supervisor: Ornella Selvafolta

Luigi Mattioni (Milan, 1914-1961) was one of the most productive architects of the Milanese Reconstruction, involved in several research fields, among which urban planning and professional renewal, as well as the debate on building industrialization and the reflection on residential, tertiary and industrial building typologies. The city of Milan – with around 80 building complexes carried out by the architect and documented within the municipal borders – records a substantial incidence of Mattioni's architecture, in which the themes of modern apartment building, skyscraper and manufacturing site stand out, maintaining visual importance in the city of today and arousing new interest in the rediscovery process of post-war modernism.

Considering the wide yet so far poorly studied activity of the architect – subject of publication only in 1985 – the thesis aims to analytically investigate Mattioni's career and production, with the purpose of starting a new order of critical reflections on his figure and work. In order to be as scientific as possible, the research made use of direct interviews with the architect's employees and, above all, of the first-hand and mostly unpublished documentation preserved in Mattioni's private archive, made available to the writer by his heirs

for the entire duration of the research program. With reference to the study of Mattioni's professional career, the thesis focusses on three main stages: the polytechnic education at the Faculty of Architecture of *Politecnico di Milano* in the Thirties (Chapter One); the participation in the discussion on building industrialization, housing and reconstruction in the Forties (Chapter Two); the organization of the Studio and the trade-union activities in the Fifties (Chapter Three). With reference to the analysis of the works, the dissertation develops from the interior design projects of the early years and leads to the major residential, multi-functional and industrial buildings of the maturity



1. Map of the buildings carried out by Luigi Mattioni in Milan from 1946 to 1961

(Chapter Four). Special attention is dedicated to the subject of high-rises in Milan (Chapter Five). The thesis is accompanied by a complete list of the projects and a mapping of the buildings carried out in Milan. The quantitative analysis comes out beside the qualitative one: with over 300 projects, mostly localized in Milan, Mattioni's architecture shows a far from negligible importance for the interpretation of the shape assumed by city in the years of its major expansion. The wide corpus of projects crosses in some cases the frontiers of the Milanese metropolitan area, extending throughout the Italian territory, from Trento to Catania, with a relevant ensemble in Rome's EUR district.

The discovery of the consistency of this heritage can be collaterally considered a first step toward the assessment of its today's state of preservation, sometimes linked to more recent episodes of architectural history.

Biographical note on Luigi Mattioni
Luigi Mattioni – known for his organizational and entrepreneurial skills – stands out from the postwar Milanese background as a mediator between the needs of urban redesign related to the Reconstruction and the opportunities offered by the real estate market. Anticipating today's conception of work, he set up his Studio as a modern firm, inspired by American project corporations. Trained at the School of Architecture of *Politecnico di Milano*, Mattioni graduated in November 1939; the projects of the university period and the first settings, carried out right before the war, already showed the affinity of the architect to an International Style adhering to the codes of the Modern Movement. In 1944 Mattioni's participation in the debate on building industrialization took start through collaborations with architectural reviews and institutions interested in the problems of reconstruction and prefabrication. The most tangible outcomes of this phase consisted in scientific and technical research on housing (dimensioning, orientation), studies for prefabrication and organization of architecture exhibitions, including several contributions for the Eighth edition of the *Triennale di Milano*. The research on building standardization, doomed to fail in the Italian context, characterized

by an inertial maintenance of conventional construction methods, persisted in the *modus operandi* developed by Mattioni in the Fifties. His residential building complexes, sometimes based on "preprojects" designed in a record time of only two days of work and characterized by recurrent morphological solutions, are still scattered throughout the Milanese territory, as serial elements of a unified urban landscape.

Aside from an ordinary residential production, Mattioni approached big projects and urban plans, among which point-blocks and skyscrapers, conceived as experiments of *open planning*, explicitly opposed to courtyard, still adopted as a recurring building pattern by the City of Milan. The "Skyscraper of Milan" in piazza Repubblica, as well as the Terrazza Martini Tower, in the heart of the city, or the master-plan for the Turati Towers, at the edge of the Milanese downtown, are some of the most famous results of his research on high-rises.

The icon of the skyscraper embodied the dreams and ambitions of its time, stimulating new reflections on the future of the metropolis and its infrastructure: in a futuristic, although unrealized, urban project, Mattioni elaborated a study for the construction of thirteen reinforced concrete towers arranged in a ring around the city center, on top of which the stops of an aerial cableway were to be located. In a *megastructural* vision *avant la lettre*, Mattioni even imagined skyscrapers made of residential cells obtained from the coachwork of the buses, attached to the pillars of the "aerial metro" as plug-in or clip-on units.

Over the last few years, the main efforts of the architect shifted from the field of design to that of the defense of professional rights. Concerning associative activities, Mattioni was one of the most engaged members of the Lombard Regional College of Architects; as a trade unionist, he reached the top of the sector between 1959 and 1961, chairing the National Trade Union Federation of Freelance Architects. He was also an INU associate and a founding member of the In/Arch Institute, which attributed to his work the In/Arch prize 1961 for Lombardy as last award.



2. L. Mattioni, Design for the Diaz Center in Milan (Terrazza Martini Tower), 1953 (Luigi Mattioni Archive)



3. L. Mattioni, Technical office building Ercole Marelli in Sesto San Giovanni (Milan), 1959-1962 (Luigi Mattioni Archive)

CIVITA DI BAGNOREGIO STUDY CASE. STUDIES FOR THE ANALYSIS OF AGGREGATE BUILDING'S SEISMIC VULNERABILITY

Giulia Campanini - Supervisor: Paolo Faccio

Co-supervisor: Carolina Di Biase

The recent development of the concept of prevention of cultural heritage highlights the necessity of create a new shared and uniform methodology of knowledge of the historical buildings. The increasingly reduced resources devoted to the protection of the historical and artistic heritage makes this action, focused in management and use of funds available, necessary, in an afford to streamline and forecasting of interventions. In relation to these considerations, the possibility of developing methodologies organized and structured reading, restitution and interpretation of architecture, allows to define strategies for the protection, no longer focused on emergency but based on preventive survey but based on the lecture of the sequence of constructive transformations. Moreover, recent rules - even if currently in a draft form - directs to comply the need to achieve the highest level of security with the demands of preservation, emphasized the fundamental role of knowlodge in understanding the complexity that characterizes the study of aggregates buildings. In this perspective, the proposed study addresses the issue of the

definition of a qualitative and multiple risk methodology for the evaluation of the seismic vulnerability of the historical aggregate building. This step was discussed on a study case individuated in the ancient Etruscan village of Civita di Bagnoregio (VT). The historical center was considered an ideal study case for the tangible presence of risk issues related to the hydro-geological and earthquake history and for the a high level of constructive complexity as a result of constructive dynamics linked both to the development of the property and to external risk factors. (img. 1) The methodology takes into

account different hazard typologies which were identified for construction in this studied site (i.e. seismic, hydro-geological, anthropic risk). At first, were collected descriptive contributions of the particular hydro-geological conditions, the seismic history and the constructive transformation at different historical thresholds. This data, sorted in the second part of the study, helped define an overall picture of the existing; showing not only the development of the hazard issues and the building transformation process, but even more, highlighting the close relationship between these elements. In the last part of

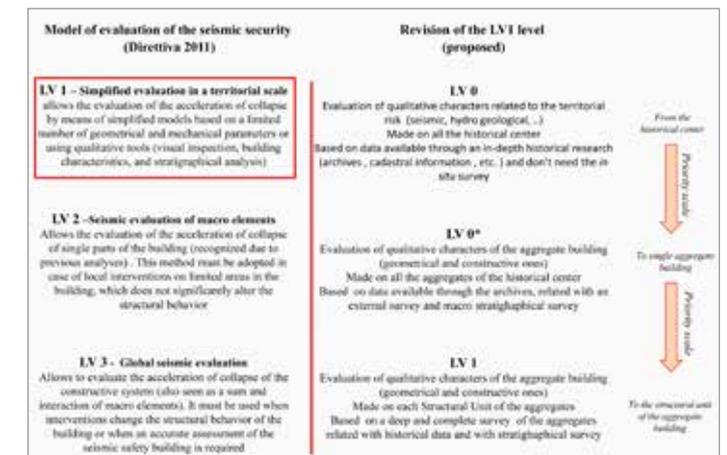


1. Civita di Bagnoregio study case. Photos by the Author.

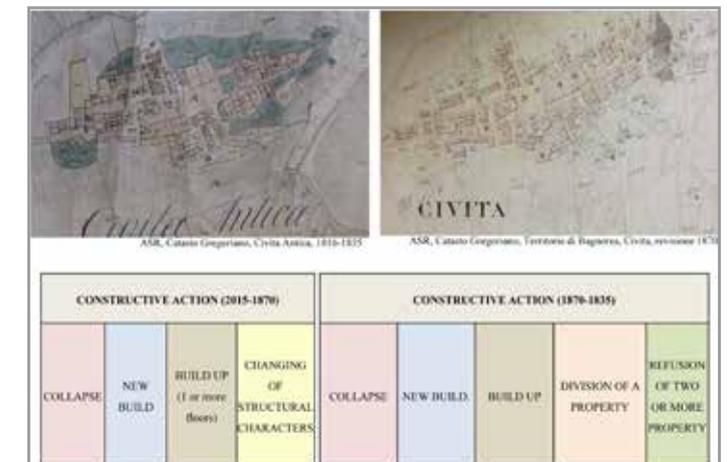
the research is proposed a first matrix of vulnerability taking in account the relation between the risk issues and the constructive transformations occurred over the time. During the research, the reading of the historical data has allowed us to extend the recognition of the constructive evidence and, in parallel to the stratigraphical survey, has provided a support to the recognition of the constructive transformations. Moreover, this analysis allowed to recognize the constructive aggregation phases, reported by reading the ante post reports, and, in relation with the cadastral data and the analysis of construction material, has helped to define a chronology of architectural transformation. In conclusion it was proposed a simplified model of vulnerability assessment on three cognitive levels with respect to the degree of knowledge needed. The first two level - defined in levels LV0 and LV0* - describes the exposure of the aggregate complex to different risks. The LV0 level describes the different hazard of the site and is based on technical documentation retrieved in the main archives without a site survey. The LV0* level describes vulnerability in relation to each aggregate. It needs a historical analysis based on cadastral studies and macro stratigraphical surveys. The value is based on the identification of the irregularity of the complex related to the form (plan, elevation) and to the constructive process (transformations, conservation). The third level - called LV1

- gives a qualitative value of seismic vulnerability related to each single structural units of the aggregate. It is based on the same factors of the previous one but with a further study on each structural unit composing the aggregate. At the end of this research was evident how individual disciplines can contribute to define an

innovative model of analysis and evaluation of seismic vulnerability of buildings in the aggregate. However it is clear that the methodology needs to be tested on other study cases in other to give a value to each factors of the three level.



2. The methodology of the study related to the D.P.C.M. 2 febbraio 2011 (the last Italian norm about seismic vulnerability of buildings).



3. The XIX century cadastral maps of Civita di Bagnoregio show the presence of important constructive transformation, investigated in the different level proposed.

TRANSFORMATION AND CONSERVATION OF THE HISTORICAL NATIONAL MUSEUM: THE PINACOTECA DI BRERA, 1946-1998

Giuseppina Di Gangi - Supervisor: Caterina Bon Valsassina

Co-supervisor: Stefano F. Musso

The aim of the research is to analyze the architectural transformations (with structural, material, spatial and aesthetic aspects involved) occurred in the Pinacoteca di Brera in over 50 years, ranging from post-war reconstruction, due to Piero Portaluppi and Franco Albini's project, to the late twentieth century.

Going through these latest changes the study tries to decipher the heterogeneity that characterizes the current arrangement of the museum and to recognize the spatial and material values that define the identity of the museum, that must be conserved and preserved in the vital process of the museum's evolution.

The research is related to the recent cultural and scientific debate about renovations of museum arrangements that still represent an important expression of architectural modern language. Architectural interventions on museums, in fact, are often oriented to the functionality of the exhibition of the artwork and to the accessibility and safety of visitors, ignoring the implicit value of the space itself, which is therefore destined to inevitable transformations in the name of intentional renovation or functional adaptation.

The Pinacoteca di Brera 50's

reconstruction was characterized by a strong adherence between structural project and architectural design and by specific luministic and technological solutions, reflecting the methodological approach to the restoration at that historical juncture and the industrial development and production of the time.

In the late 70s, in the background of the critical debate gained on degradation and on the absence of a museum management policy, moreover after the 1968's cultural revolution that submitted the museum to a reflection in terms of its social function, we can notice the first transformations of the postwar arrangement museum of Brera.

Although in those years begin a new cultural approach to the

restoration of historical building, keeping in mind the importance of preserving material aspect too, the renovation/restructuring of the museum directed by the Superintendent of Monuments between 1978 and 1980 is still based on aesthetic judgment and on a stylistic re-composition.

Since the '80s, the need to keep up with the technological advancement, the development of legislation about safety and accessibility of public spaces, but also the purpose to re-think "the image of the museum", led to a new project entrusted to the studio GregottiAssociati.

The project's intention, as revealed by drawings and reports, was based on the critic choice of preserving some specific features while changing others, but clashes



1. Pinacoteca di Brera, room 1, the 50's vaulted ceiling designed by architect Piero Portaluppi and the current one after the 70's stylistic re-composition. Courtesyarchivio fotografico Soprintendenza beni storico artistici and Soprintendenza beni architettonici, Milano.

with the political and economic difficulties that considerably restrict its realization.

These problems should be seen in the Italian social and political context of the 80s, when the inflation and unemployment lead to an allocation of funds based on return in terms of employment and social impact; it was called FIO (Investment Funds Occupation). The forced extension of such funds to the cultural heritage proved to be inadequate for the specificity and complexity of works, consequently many project remained incomplete, including Brera, Palazzo Pitti in Florence and the pole museum of Taranto.

The architectural traces of the recent examined past of the Pinacoteca show some important and complex knots critical insights, which cannot be ignored in the next intervention approaches, but also involves general consideration on the difficult relationship between conservation and renewal of museum arrangements.

One of the theme that the present research has stressed is that concerning the possibility to re-establish an arrangement, that represent an important document for architectural language, when, even if it's altered, significant traces remain clearly visible. That's what concern the museum wing where an interesting luministic solution was designed by the architect Franco Albini in 1950.

It proves essential to discern between original elements (the shifted roof, the signs of the original panel support), replaced element (the windows' glass and their original function), lost elements (exhibition panels,

curtains), modified conditions (a new fire escape opened), and even between the original project as conceived and as realized.

More complex questions arise from PieroPortaluppi's complete museum arrangement, because of the introduction of many irreversible structural, material and formal changes within a recognizable original architectural configuration.

An essential question concerns the skylight solution, as we stand today facing a situation strongly altered: original 50's skylights drilled from the air vents, closed skylights and finally new volume 80's skylights that also integrate the new air conditioning system.

Finally, we can't ignore that some 80's project characteristics can be considered historicized themselves, for example the use of iron burnished padded and thresholds, that partially replaced the previous marbles but also hide some compartments in which devices of security and service are



2. Pinacoteca di Brera, Raphael's room, the setting realized by the architect Piero Portaluppi (1950) and the new arrangement commissioned to the architect Vittorio Gregotti (1982). CourtesySoprintendenza beni storico artistici, Milano (left); photo Aldo Ballo (right).

placed.

Moreover, there is the question about conservation/renovation of the current Raphael's room designed by Vittorio Gregotti with the superintendent Carlo Bertelli in 1982. It completely removed the previous postwar configuration organized in three small rooms, but also introduced a new museum concept beyond mere structural and materials transformation: the architect himself defines it the expression of a "new cultural attitude".

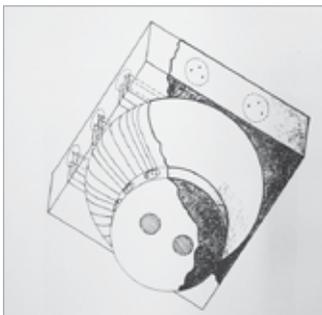
All this shows the rich and interesting complexity of the current museum and the critical challenges it presents. This research aims to reveal the reasoning behind the past interventions by interpreting their traces still present in the Gallery today and hopes to present a useful tool for future interventions.

BEHAVIOR AND DURABILITY OF “MIXED STRUCTURES” IN ARCHAEOLOGICAL AREA. THE TEMPLE OF PYTHIAN APOLLO AT THE ACROPOLIS OF RHODES.

Elisa Fain - Supervisor: Carolina Di Biase

The use of cement-based materials for restoration of historical buildings during the 20th century strongly contributed to increasing their constructive and structural complexity. With particular reference to reinforced concrete, it found a widespread use for many different interventions and turned out to be particularly useful for anastylosis of ancient stone buildings in archaeological areas, granting the reassembled ancient stones a new equilibrium. Nowadays, reassembled “mixed structures” in archaeological areas put many issues for conservation, investigated by this research: from an overall re-thinking of their historical and cultural significance, to the possibilities and limits in investigating their current structural behaviour, to the necessity of a specific approach in evaluating their residual structural safety.

The methodology chosen provided an overview on the use of reinforced concrete for restoration in archaeological areas during the 20th century, based on historical and current literature and in-situ inspections. The reasons of concrete's success are investigated through many cases, with references to the excavation campaigns and restoration works by the Italian Archaeological Missions in the Mediterranean



1. Selinunte (Sicily), Temple E, capital n.19. The drawing shows the project for a reinforced concrete integration realized during the Temple's anastylosis by Iole Bovio Marconi (1956-1959).

between the Twenties and the Seventies (fig.1). On the whole, it is possible to state that the use of reinforced concrete marked Italian anastylosis for many decades; at the same time, the great variability of geometry, materials and technical solutions adopted in building yards, strictly depending on contingent conditions and the absence of executive projects, made every case singular and different from the others. Furthermore, time has often demonstrated an intrinsic lack of durability of archaeological remains where different materials coexist, chiefly due to chemical and physical interaction among materials and decay processes, accelerated by the overall aggressive environment of archaeological areas.

Bad state of conservation of mixed structures in archaeological area led to well-known campaigns for the removal of modern interventions. These cases demonstrated a quite total irreversibility of reinforced concrete interventions and unavoidable extended new integrations. This research highlighted that this approach could become a procedure on mixed structures, if their historic value is not recognized, even when their state of conservation still gives a chance. Decay of mixed structures in archaeological area has also other effects: it affects the resistance of materials and the rigidity of constraints and makes it even more difficult to state the most probable actual structural behaviour of the objects.



2. Acropolis of Rhodes (Greece), Temple of Pythian Apollo. Detail of the entablature reassembled between 1938-1940 by Italian Archaeological mission with the aid of reinforced concrete.

Therefore the research tested a focus on a case study, the Temple of Pythian Apollo on the Acropolis of Rhodes (Greece), partially re-erected with the aid of reinforced concrete between 1938 and 1940, to outline an approach to study “mixed structures”, chiefly aimed at the comprehension of structural behaviour and at the evaluation of structural safety (fig.2).

Deepening and interlacing different disciplinary approaches, collecting information from site surveys and archival records and comparing it to previous investigations and studies, the research highlighted that synthetic models offered by the Building Science (cf. rigid body and frame model) aren't reliable enough for a numerical evaluation of the structural behaviour of the considered structure. Similar difficulty could be reasonably extended to many mixed structures in archaeological area.

Nevertheless, this approach allowed to make some qualitative evaluations on the behavior of the structure, when it was in a good state of conservation. With particular reference to the peculiarities of the Dodecanese region, interested by high seismic hazard, the research permitted to make qualitative evaluation on the behaviour of the Temple under seismic conditions. Its seismic capacity during strong earthquakes confirmed the objective of its preservation also from a technical point of view.

Time can easily decrease structural capacity and the case study of the Temple of Apollo exemplifies some general issues related to the state of conservation of mixed structures

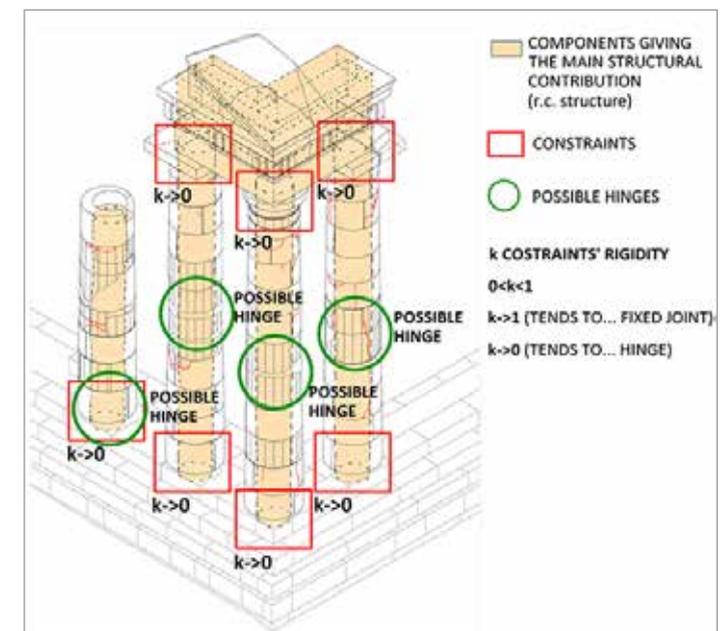
in archaeological areas.

The present study permitted the assessment of the most probable damage mechanisms at the current state of conservation (fig.3). Overall, even if synthetic models are barely reliable for numerical evaluation of mixed structures, they can describe qualitatively their behaviour, also in seismic conditions.

In light of the outcomes of the research, the present thesis work aims to prove the importance of the preservation of mixed structures as a document of the Twentieth-century, when it is still possible.

Since mixed structures are often the outcome of building yard praxis, categories are counter-productive and the study of every object need specific attention. The methodology adopted, based on multidisciplinary study and

including information on the recent past, allowed qualitative assessment of the structural behavior of the construction; with particular reference to archive records, they gave an important operative contribution. In order to hold together the objectives of preservation and structural safety, the level of structural protection of the mixed structure has to be chosen carefully. On the whole, the thesis affirms a lower level of structural safety for mixed structures associated with a project of conservation and fruition of the archaeological site. In the future, a similar approach could bring to the definition of a specific state limit for archaeological remains (maybe detailed on each structure) based on its specific constructive characteristics and fruition.



3. Temple of Pythian Apollo, hypothesis of reduction of constraints' rigidity and possible damage mechanisms (author's elaboration).

ABSTRACT: THE EVOLUTION OF RURAL BUILDING TECHNIQUES IN THE CENTRAL PO VALLEY BETWEEN 4TH AND 14TH CENTURY

Chiara Marastoni - Supervisor: Alberto Grimoldi

Co-supervisor: Fabio Saggiaro

This research aims to recognize the chronological collocation of structural traces, dating back from the 4th to 14th century, in a wide portion of the central Po Valley - which includes the main districts of Mantua, Cremona and parts of Brixia - starting from a survey of the Archaeological Superintendence's archives of Lombardy. The evidences studied have contributed to widening the number of known Middle Ages settlements, whose lack has often been lamented by scientific literature.

The medieval building survey immediately shows the presence of two main data categories, both characterized by problematic aspects of analysis: on the one hand, a sites' group that could be defined as "residential" (a), on the other hand examples of ecclesiastical buildings (b). In the first case (a), most of the examined excavation's contexts show archaeological traces related to a massive use of wood for architectural use (88%), that becomes almost "pervasive" from the 5th -6th century, especially in rural areas. Wooden residential housing in northern Italy is generally poorly represented in scientific literature, since the case studies published up to the end of 1990's are few in number and also

assiduously presented. Among them was the site of Piadena (CR), which was excavated in 1983, and its data were only summarized in 2005. Here different frequentation and construction periods have helped the scientific community by providing valuable information about wooden architecture in the central Middle Ages. The present research started exactly from the consultation of the documentation referred to as the archaeological excavation of Piadena, which includes some late medieval architectural evidences that were not considered in the publication. The continued study of the context of the newly-identified settlements has allowed researchers to identify a total of sixty-eight buildings, characterized by tracks of wooden architectural elements (to whom nine masonry examples have to be added), in the context of sixteen main surveyed sites. The identification of these new cases adds a significant contribution to the previously established residential architecture studies of northern Italy. Of the sixty-eight total wooden buildings identified in the present study, only negative tracks of structural and foundation elements location were preserved, with very little remaining of floors or levels of occupation. This

lack may be largely due to post-depositional phenomena or short periods of use which commonly characterize medieval wooden villages. This data's invisibility does not allow us to understand techniques and materials used in the construction of walls or ceilings with a sufficient reliability degree, so much so that traces attributable to wooden buildings have been relegated outside the Building Archaeology's discipline, as they have traditionally been more oriented to the analysis of masonry structures. These interpretative issues, however, did not prevent the opportunity to identify - in the provided cases - morphological and typological variables in buildings' plans and in foundations and bearing structures of various huts. In fact, this approach has characterized most of the analysis dedicated to the study of residential buildings in the last few decades. This one has largely focused on the identification of building typologies. The organization of the main stratigraphic data, although limited to a restricted area of the Po Valley, has led to the identification of the main wooden techniques proposed in this study - classified according to types and variants. This has contributed to

a more methodical and orderly comparison with case studies known in the scientific community, which, thus far, lack an overall form of systematization. The classification proposed in this study considers marked differences mainly in technical foundations and in weight bearing structures. Between the 4th and 8th-9th century, structures seemed to show a full recourse to a supporting frame formed by vertical wooden posts. Whereas from the 8th century on, and especially during the 9th and 10th century, the use of horizontal wooden beams appeared to prevail as foundation for walls. Similarly, a great morphological variety should be noticed in the analysis of the identified hut's plans between the 4th and 8th century (*Grubenhäuser* can be found among them), that decreases to only two main planimetric conformations starting in the 9th century: rectangular and "complex".

The wooden building typology of the central Po Valley may therefore underline a period of transition between the 8th and 9th centuries, which has been remarked on in other areas of central and northern Italy by various researchers (such as Gelichi, Librenti 1997, Augenti 2004).

To the collection of evidence of the use of wooden elements - called more generally "perishables" - for building's construction, this study has added the analysis of masonry structures, which should involve the use of more sophisticated production cycles in connection with a high customer base which

is able to recall the presence of skilled labor. The examination of this type of buildings highlighted the construction and renewal of large late-antique residential villas next to wooden huts, between the 4th and 5th century. The sites of Palazzo Pignano (CR) and Desenzano (BS) - loc. Faustinella show the use of river stones and fragmented bricks, arranged in regular courses with lime mortar, effectively creating masonry walls. Among the residential settlements considered in this study, the use of masonry cannot be detected until 10th -11th century, when a massive wall made up of river stones and abundant lime mortar was identified in Castel Goffredo (MN) - Gonzaga square. Eventually, between the 12th and 14th century, the recorded data seem to show a growing number of private houses containing masonry walls, in which newly produced bricks can be identified, though in a small quantity compared with the wooden structures.

In the second identified category (b), the constructive solutions related to the ecclesiastical sphere in the studied area have been considered. However, they have been limited to the data available in the Archaeology Superintendence's databases, according to the results of the archaeological excavations. The examination of masonry construction techniques related to ecclesiastical buildings has allowed us to detect the presence of two main structural elements: collected materials and newly produced bricks. Until the late Middle Ages, in the archival records related to excavations

carried out in religious buildings, a wide use of recovery elements and river stones could be noticed. They were set in place through the use of clay or lime mortar. On the contrary, from the 12th -13th century, a widespread use of new format bricks has been found. They were probably specifically produced for new churches and chapels. Their production issues should be examined with further studies at a regional level, paying attention to a sampling of the far more numerous buildings that survived at a higher elevation. The identification of a medieval brick form's presence in the analysed cases was especially helpful to propose a clue about the issue of the production of bricks from late antiquity to the 14th century. In fact, along with the recognition of medieval clay elements of construction, the study highlighted a data invisibility of productive places. In order to explain it, different causes have been identified, such as a lower use of newly manufactured material, along with reasons related to methodological problems, also contemplated within the scientific debate.

LIBERO CECCHINI ARCHITECT IN VERONA FROM THE AFTER WORLD WAR SECOND TO THE EIGHTIES

Giorgia Ottaviani

Supervisors: Maria Antonietta Crippa; Francesco Doglioni

Libero Cecchini (Verona, 1919) was one of the most significant architects within Verona from the Reconstruction of the city after the world war second. After he completed his formation at Politecnico di Milano, he started a long and advantageous cooperation with Piero Gazzola, infact Cecchini was involved in several areas of resarch and, with his "pervasive" work, he contributed to redefine Verona's architectural aspect. Basically Cecchini's education, related with his professional beginnings, concurred to create a figure that could represent the continuation of the tension, perceived in Italy after the end of the World War Second, through his long professional life. The research begins from the possibility of studying unpublished documents preserved in the private architect's archive (subdivided in different buidings); then it was enlarged, to have a wider perspective, to some other archive: Verona's City Administration archive, Licisco Magagnato's archive, Piero Gazzola's archive, Politecnico di Milano historic archive, and national and local press. This work outlines the stages of Cecchini's career: the education through the cultural environment

of his younger years, the schools he attended, and the polytechnic attendance at the Faculty of Architecture of Politecnico di Milano; the years of the Reconstruction; the professional activity in from the Fifties until Eighties open to each purview, in particular to the new technological method with the stone. The research work has been structured into two distinct parts: the first that deals with broader issues (training, analysis and list of works; Reconstruction with the general theoretical problems linked to it, and the principal details of the city of Verona); and the second in which are analyzed study cases starting from the experimental applications, focusing the

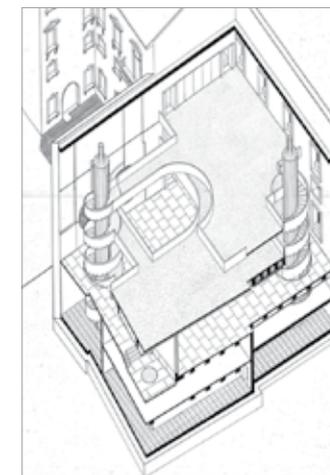


1. The Cagliari's museum complex view from the city below

attention on technological method of prefabrication and precompression using naturale local stone; until the analysis of restoration works of the maturity. The chapters are in-depth general topics, which are then declined in relation to the figure of the architect and his work. The parts of the work are then linked to each other by a large discourse, built to give way to understand the multifaceted Cecchini's personality, who worked across the board within the profession: from urban to design, from technological experimentation to restoration. In the core of the work special attention is dedicated to some episodes, key elements in Cecchini's career: the complex of the Cagliari Museum Citadel,

designed with Piero Gazzola (1956-1976); the headquarter of Banca Cattolica del Veneto in Palazzo Mosconi in Verona (1967-1973); the project for the roman Porta Leoni's archaeological area in Verona (1974-1982); Palazzi Scaligeri's project reorganization (1976-1996); set of projects for San Zeno Maggiore Abbey (1984-1996). They are all located in Verona, except for the first one, chosen and inserted into this research not only for the importance of the co-designer, the superintendent Piero gazzola, but also for the issues addressed in it, related to museology and museography, modern architecture insert in contact with "ancient" ones. They were chosen as reference cases, in which the architect faces for the first time general problems, focusing on a language, that then Cecchini will reuse and decline from time to time. An integral part of his expressive figure is the constant use of local stone also widely known for family tradition (Red Verona marble and its many other varieties), and the massive use of reinforced concrete facing. Both materials are indiscriminately used in any type of work, transporting modes of expression from his works on ancient monumental building to his modern architecture works.

His works are thus the complete expression of an architectural vision, one that can be interpreted formally, structurally and functionally, without sepatations between taking care of the existing and inveention of the new. With reference to the analysis of the works, the dissertation develops from the review of the wide architectural works. Finally the thesis is accompanied by a complete list of the projects and a mapping of the buildings constructed by the architect in Verona.



2. Palazzo Mosconi in Verona, isometric view of the structure



3. The roman Porta Leoni in Verona, view of the project for the archaeological area

BETWEEN REALITY AND UTOPIA THE SICILIAN EXPERIENCES OF BORGO DI DIO, MIRTO AND MONTE DEGLI ULIVI AS PART OF THE ITALIAN SCHOLASTIC EXPERIMENTS IN TWENTIETH CENTURY

Lucia Pierro - Supervisor: Maria Antonietta Crippa

The design of “learning architectures” deals not only with specialistic and multidisciplinary issues, but also more generally with the conception of the younger generations’ education. These crucial issues of the civilian life are related to the condition in which specific educational guidelines are designed and implemented, aiming at building the common cultural values that individuals can share with their own community. Places of community for excellence, school buildings accommodate history, present and the project for the future of the community to which they belong. At the same time, they also become the laboratory in which the memory and the common knowledge that contribute to build the identity of a nation are designed and transmitted.

Leaving in the background the entire national process that took place during the Twentieth Century, with several experiments on school buildings and parallel studies for the definition of models and educational theories, this research explores three experiences in Sicily in order to grasp their singularity, their driving force and their fertility. The research “Between Reality and Utopia: The Sicilian experiences of Borgo di Dio, Mirto

and Monte degli Ulivi as part of the Italian scholastic experiments in Twentieth Century” focusses on the two architectural complexes for education promoted by the sociologist and educator Danilo Dolci in Sicily, the village of Borgo di Dio and the Educational Center of Mirto, located in the province of Palermo in the territories of Trappeto and Partinico. It also analyses the parallel and coeval Village of Monte degli Ulivi, located in Riesi, sponsored by the Waldensian Pastor Tullio Vinay and designed by the architect Leonardo Ricci.

The research clearly shows the utopian dimension of the three Sicilian educational experiences developed between the fifties and seventies of the Twentieth Century. This decisive experiment has caught national



1. The courtyard of the architectural complex “Borgo di Dio” in Partinico

and international attention, also in a controversial manner. It shows the process leading to the definition of an educational method which included the participation of the lower social classes, characterised by their great poverty and their precarious life. The promoters who supported this process were convinced that a dynamic social life, together with school education, were key for the communitarian life of the population, understood as the primary political body of the nation.

The case studies that I have investigated show experiments of communitarian life with their own specificities, implemented from the education of the primary schools, based in marginal and rural situations that could be

found all over Italy at that time, not only in the southern regions. The main specificity of Borgo di Dio, Mirto and Monte degli Ulivi is related to the methods for the inclusive involvement of the populations sought by their promoters and the participatory process that involve the local communities, making them an active subject in the definition of an architectural as well as of an educational project. These Sicilian places are the result of a process that aimed to renew society through the construction of new forms of community capable of expressing both modernity and respect for contextual values.

They are built to educate new communities, based on the principles of active education, as well as outdoor education understood as a tool to promote contextual values through forms of exploration and knowledge based on a direct and continuous relationship with reality. Borgo di Dio, Mirto and Monte degli Ulivi are places that tell stories of utopias and of impulses for change. In spite of their peripheral location, they document specific architectural solutions developed in a region that has been able to dialogue and engage with other cultures and to bring its contribution to a wider debate of international

concern. All this has given shape to buildings in which local and global coexist and reconcile; where traditional building techniques and forms of modernization of manufacturing processes can meet, and in which there is an attempt to found the relationship between architecture and nature in the great utopia to build a community for finally freed men.



2. The view of the complex school of Mirto from the amphitheater excavated in the hill of Trappeto



3. View of the outdoor spaces of the Kindergarten of the “Monte degli Ulivi” in Riesi

THE MUNICIPAL THEATRE OF ADRIA: KNOWLEDGE PRELIMINARY TO PRESERVATION OF HISTORICAL REINFORCED CONCRETE

Paola Scaramuzza - Supervisor: Paolo Faccio

This research aims to specify a knowledge path as a specific prerequisite to the preservation of architectures built with historical reinforced concrete, in order to find a compromise between safety and preservation.

This study shows how the constructions made by historical reinforced concrete, and ancient architectures that have undergone adjustments with the same technologies, constitute a wide heritage composed of buildings whose historical and documentary value is totally, or in large part, linked to the existence of these materials and executive contents. Currently these buildings are often transformed because of the degradation of the material, which needs both conservation or consolidation intervention, both functional and regulatory adjustments, and this is especially evident in buildings for public use. The latter circumstance has addressed the choice of the case study, the Teatro Comunale di Adria built between 1932 and 1934, one of the few theaters totally built during the Fascist period, with a reinforced concrete structure designed by Luigi Santarella, engineer, the author of one of the most important handbook about concrete in Italy. This case study allows a reflection on the need to improve the

preliminary cognitive approach to the intervention's choices. For what concerns the current legislation it doesn't seem to be able to guarantee the preservation neither of the material and constructive features nor of structural elements that are now considered as witness of the beginning of "modernity". Taking into consideration what we've just analyzed, the historical evolution of the theater buildings is a focused review that point out the role played by reinforced concrete both in new construction and in renovation of architectures. This new building technic offers, even in the case study, possibility of expression and of organization of the spaces that go beyond the

mere solution of technical and functional problems. While the characteristics of reinforced concrete are studied through the analysis of historical rules that arise and change intensively in the period between the wars, in specific between 1907 and 1939. Therefore the objective of allowing the coexistence of the regulatory adjustments with the preservation requests is particularly urgent, as long as they respect the obligation to achieve adequate levels of structural safety. For the development of this theme, and for the exemplification of the theater, the study was focused mainly on the NTC08 (Norme Tecniche delle Costruzioni



1. The Municipal Theatre of Adria, facade

2008), in order to understand how this code can allow to achieve a knowledge of the structure that can lay the foundations for an intervention that it would be able to meet both safety requirements, and preservation requirements. The knowledge path as reported in the reference code, such as, for example, the NTC08, appears, as already discussed, not enough clear to understand the historical technical peculiarity. It seems not sufficient, in particular, to relate the historical research and the implications in terms of a more detailed definition of the remaining capacity of the building, which is actually something understandable as it applies indiscriminately to all existing buildings.

The main purpose of this research is indeed to evaluate, through the case study, the ability to maximize the knowledge of the structure in order to minimize the interventions needed today for structural adjustment, safeguarding not only the formal aspects but also the technical content of twentieth century Architecture.

The period studied, covering a time lapse of twenty years, in terms of materials, methods of execution, assumptions and design regulations, it has special features in comparison with the previous time and the one that will come after.

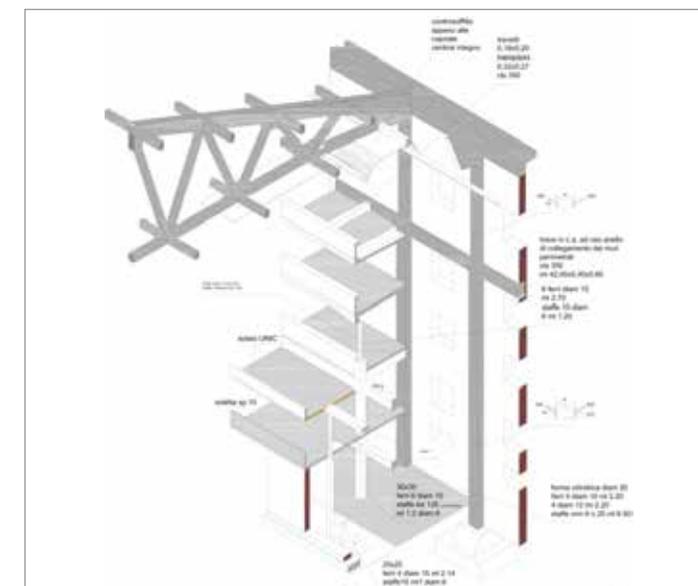
Indeed, as is clear from the study of historical regulations regarding reinforced concrete structures, in a limited time frame, as the period between the wars, there are numerous standards that evolve in relation with the evolution of

the studies and the experimental tests.

Comparing these standards it is possible to see, for example, how some reference mechanical values, are modified over the time. Furthermore the different regulations depending on the year to which they refer, provide important Information concerning the construction details and construction techniques which, as noted, can affect the quality and



2. Roof trusses designed by Luigi Santarella



3. Theatre model based on archive documents

durability of the structure. Historical research then has allowed to point out the peculiar aspects that characterize the architecture built by reinforced concrete at the beginning of the past century and, as a result, to design the diagnostic phase going to minimize the number and invasiveness of tests, with the design of a true knowledge project directly to the building. This research intends to emphasize the primacy of a careful and detailed knowledge that wants not really to oppose but to specify a process that right now seems too much syntetic and oriented to simplify the analytical and interventional procedures instead of carefully understanding the existing.

GALLERY VITTORIO EMANUELE II IN MILAN. THE IRON-GLASS COVER: INNOVATION, CONSERVATION, CONTINUITY

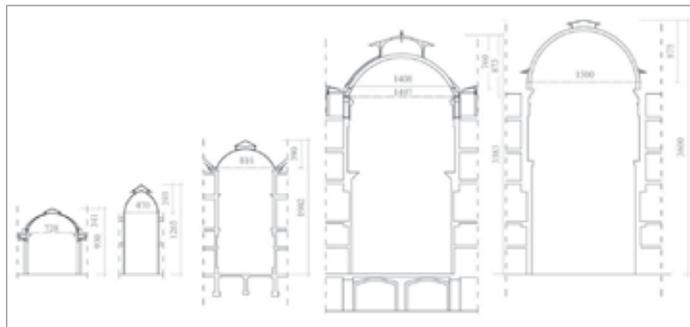
Iva Stoyanova - Supervisor: Ornella Selvafolta
Co-Supervisor: Amedeo Bellini

Gallery 'Vittorio Emanuele II' (1865-1877) in Milan constitutes one of the most remarkable examples of 19th-century European arcades still standing today. The history of its ideation as a large-scale urban operation in the heart of 19th-century Milan, its architectural design and construction reflected significant national events and complex cultural values. The Gallery represents an emblematic piece of heritage especially as an example of the monumental Italian urban architecture. One of its outstanding features is the iron-and-glass roof: it had been unmatched in dimensions and monumental impact by the already constructed arcades. The dome was especially celebrated on international level as a significant example of 19th-century iron-and-glass architecture. Moreover, the design and installation of the roof were acknowledged in previous studies as the result of international collaboration as regards funding and exchange of technical knowledge.

Past research discussed the Gallery as a complex multifaceted 19th-century phenomenon with multi-fold importance on national and international level. This thesis focuses on the significance of the Gallery as an emblematic

example of 19th-century iron-and-glass architecture from the arcade typology which has survived into the present day. Due to this significance, the Gallery roof merits a more profound investigation in terms of original construction technology, creativity and monumental spatial effect. The present-day necessity to intervene in the roof structure standing in place today raises a number of questions with regard to adequate preservation. These questions need to be addressed and deepened in a systematic and methodological manner. The thesis proposes the answers to two main questions among others: to what extent the roof standing today is in continuity with the historical structure and how the historical, technological

and architectural identity of the roof today as an integral part of the Gallery can be defined. Therefore, this thesis investigates with special regard to the iron-and-glass roof the complex origins of the Gallery, the construction history and the interventions from the completion of the construction works until today. Archival and documentary research has unveiled unpublished graphic sources. These allow "reconstructing" the building logic in further detail than in the already available knowledge. For example, light has been cast on the original glazing system and the relevant construction details. Comparison to preceding arcades (Fig. 1) highlights the deep relation between the roof technology and



1. Cross sections of emblematic arcades and their dimensional growth. From left to the right: Gallery d'Orléans, Paris (1828-1829); Royal Galleries Saint-Hubert, Brussels (1845-1847); Gallery Jouffroy, Paris (1845-1847); Gallery Vittorio Emanuele II, Milan (1865-1877); Gallery Umberto I, Naples (1887-1891).

the monumental effect that was pursued with the Gallery architecture. Four leading examples of this relation can be delineated: an "invisible" reinforcing system balancing the lateral thrust of the cover in order to free its span of visible tie-rods; high load-bearing resistance of small cross-section glazing bars; the shape of the overlapping glass panes; their connection to the glazing bars without additional transversal profiles. These technical aspects have been deepened through the investigation of technical literature and comparisons to relevant case studies from the 19th-century building practice.



2. American newspaper commercial on the material 'Arco Sealit' which was used in a maintenance campaign for the Gallery roof in the 1920s.

A thorough examination of the history of interventions in the roof after the completion of the construction works has been carried out. Numberless cases of special and routine maintenance as well as the major reconstruction after the Second World War have been researched. Complicated maintenance issues, methods and materials (Fig. 2) have been studied focusing on the extent to which they have changed the original roof. Furthermore, the research has revealed when the traces towards a more adequate awareness for the complex identity of the cover as an essential characteristic of the Gallery has started to take place.



3. Expansion joints that were introduced in the post-war reconstruction of the roof.

Personal onsite investigations have documented the present-day state of the roof. Thus, it has been possible not only to individuate certain changes that were introduced in previous interventions (Fig. 3), but also to expand the scarce available information about the latest ones.