



Chair:
Prof. Carolina Di Biase

DOCTORAL PROGRAM IN PRESERVATION OF ARCHITECTURAL HERITAGE

Interventions on the built environment and more generally on buildings of the past, including the recent past, and their management call for fine-tuned knowledge and organization skills in all the related areas, from planning to maintenance.

Special and separate attention is paid, on one hand, to older and historical buildings and structures, on the other to contemporary architecture, in both cases in constant contact with developments in studies elsewhere in other countries.

Regarding the method, the most significant contribution of the PhD program is the ability to acquire both the learning derived from specialized knowledge, both the fundamentals of knowledge that allow to dialogue with different disciplinary matters and often complementary.

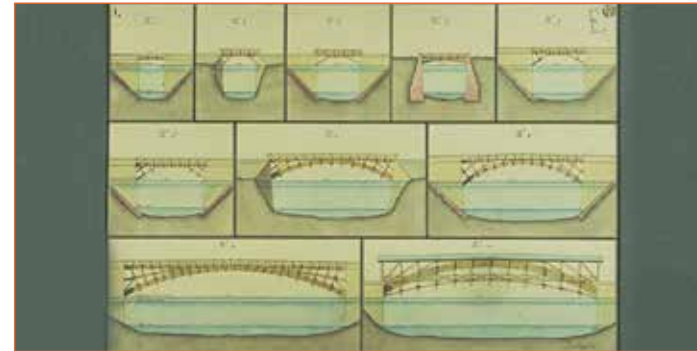
The sequence of courses and activities are designed to form a researcher and an operator that can work with high-quality in preservation activities, maintenance and management of building heritage.

Teaching aims

Knowledge is an essential step towards protecting and preserving the built environment, and particularly in the case of the "conservation of the architectural heritage", it is essential to understand complex aspects of its creation, transformation, present conditions, and consider the richness of its meanings and evidences.

In fact a building or a structure cannot be explained by the technical instruments of architecture alone: its documentary dimension lies in its material substance, in the meanings that built heritage has been assuming over time for different societies and that should be evaluated when new conditions and significances of buildings and sites are to be defined.

Familiarity with the built environment is necessarily aided by historical research and every other kind of useful contribution as well as, obviously, that by experimental science. As far as knowledge and intervention on the built heritage are concerned, the human sciences and historical disciplines are indissolubly linked with the relevant applied sciences. For there can be no "truthful", exhaustive diagnosis of old buildings that fails to consider the dimension of time, and the reconstruction of past usages and transformations. Conservation of built environment finds in the interdisciplinary knowledge as well as on people able to solve the questions by means of the contribution of different kind of subjects and studies.



1. M. F. De Vergès, *Projet de dix ponts différents en charpente, 1818*.

Coursework

The PhD is intended to offer a broad range of courses which combine theory and practice to stimulate advances in multidisciplinary research. The PhD career, held in three years, involves the acquisition of a total of 180 credits.

30 credits are concentrated in the first year and are divided as follows: 25 (minimum) offered by PhD courses organized by the PhD program in Preservation of the architectural heritage, and 5 credits offered by the PhD School. The remaining credits are aimed to personal study and research for the preparation of the PhD thesis.

In addition to compulsory courses, for each PhD candidate is organized a specific path-study that will include the attendance at other teaching activities. PhD candidates may attend courses offered by the School for Specialists in Architectural Heritage and Landscapes (*Scuola di Specializzazione in Beni Architettonici e del Paesaggio - SSBAP*), both in order to add more specific knowledge to those acquired in the courses of Master degree, and in relation to different topics of the thesis.

In support of research carried out for their thesis, students will benefit from several laboratories both in the University, and outside: among them, the Analysis and Diagnostic Evaluation of Buildings Laboratory (DiAP), the Materials tests Laboratory (DIS), the Laboratories of ICVBC – CNR Unità di Milano "Gino Bozza" and of the Institute of atmospheric sciences and climate (CNR Isac Padova). Among the activities undertaken during the second and third year there are also included the attendance to workshops, seminars and national and international conference related to individual research, with particular attention to the conferences in which PhD candidates will present the results, even partial, of their research thesis.

The PhD courses are organized in a variable number of lectures (one semester) and are complemented by study visits and seminar activities. The seminars are organized by the responsible professors – which provide information and basic bibliography- and have a systematic presence of lecturers from other Italian or foreign Universities in order to allow PhD candidates to get informed about the research in the different aspects and contexts. The lectures by foreign professors will be held in English. In the case of lessons held in a language different from English, the PhD course will organize a simultaneous translation into English language.



2. View of the ruins of the temple of Ramses II at Antinoe (Egypt).

- *Strengthening of historical building* of structures and materials deals with analytical and experimental methods for testing the efficiency of structures, including those at particular risk. It includes study and calibration of non-destructive investigative techniques for structural diagnosis, as well as theoretical and experimental study of appropriate non-invasive techniques, amongst them compliance with safety standards for buildings in seismic areas.
- The *Culture and experiences of heritage preservation* is approached as part of the history of culture getting to contemporary events; as history of the change of the ways of thinking about preservation and its frontiers and change in the expression of different cultural and institutional aspects. Preservation is also considered as history of criteria and types of design and interventions that vary in time, up to the introduction of new intervention techniques, materials and forms between XIXth and XXth Century.
- *Construction history* explores the issues of recognizing buildings as a historic source, interpreting how events unfolded at building sites and how production was organized, and showing how construction techniques of the past evolved thanks to the technical know-how of architects and builders, on one hand, and the methods of archaeological stratigraphy, also in elevation, on the other. In parallel students conduct workshop analyses and learn to interpret their findings.
- *Historical research methodology* aims to outline, through a selection of case-studies, the methodological and research aspects undertaken by researchers connected with different historical

disciplines, with bibliographical readings in relation to the cultural interpretations that have influenced the site transformation during the time.

Research organization and topics

One of the distinctive features of the PhD course is that it explores issues as yet seldom addressed in the sector of conservation, as a means of developing new contributions to scientific output. Particularly there are analysis of materials of contemporary buildings and their decay, the research of intervention techniques respecting the cultural heritage; the topic could be extended, starting from monumental building, to the wider field of common ones; the heating and plumbing systems of historic buildings, “building physics” (already studied in Germany and France) and the consequent documenting of innovative installations in old buildings with the parallel study of old installations in individual buildings and at urban level.

Experimental and workshop activities about famous buildings or less known are carried out in the Laboratories that collaborates with PhD Doctoral program. Innovative studies are being conducted in this sector, thanks to new research tools: the particular subjects of interest are historic mortars, old concrete, new mortars for masonry restoring. The objective is to find out how they were produced in the past, something little is yet known about, and current possibilities for re-introducing their use, or to research suitable and compatible materials and techniques of interventions.

Other more usual subjects of research and specialized teaching are the economic aspects of conservation, legislation to cultural heritage,

archaeological sites and landscape conservation, museology and museography. The PhD program fosters contacts with government institutions – starting from the Ministry for Cultural Heritage, in its central and regional offices – and with organizations operating across the country in the sector of preservation. Within this framework

several bodies have financed scholarships. Graduates of the PhD program have often found employment in public sector conservation institution at progressively higher levels, as well as in professional practice and in the business world, in specific specialized fields.

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THE COLUMNS OF THE TEMPLE OF RAMSES II AT ANTINOE. SURVEY FOR A CONSTRUCTION HISTORY OF THE BUILDING

Michele Coppola

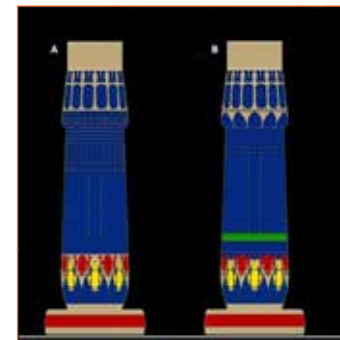
This research is a result of the collaboration between the Ph.D. school in Preservation of Architectural Heritage of the Politecnico di Milano and the Italian Archaeological Mission in Antinoe, coordinated by the "G. Vitelli" Papyrological Institute of Florence. The remains of the city of Antinoe are located near the village of El Sheikh Abadah on the right bank of the Nile, in the district of el-Minya in Upper Egypt. The city is known for being founded by Emperor Hadrian in 130 AD on the site where his favored Antinous, according to the tradition, was drowned in the Nile. The Ramesside temple represents the only evidence of the Pharaonic period, older than the roman foundation. The aim of this research is to assist the ongoing study on the temple of Antinoe to deepen the knowledge about the construction history, techniques and materials. The intent is to propose an interdisciplinary, reliable and effective method, able to achieve good results with the use of relatively simple means, that can find a right place in the current dimension of the architectural research on Egyptian monuments. The usual topics of egyptological investigations on the pharaonic architecture were combined with those of the "archeology of architecture". The investigation

focused on 14 columns of the courtyard, where the relief decoration was carved on the stone and plaster layers. Due to the abundant traces of layering these columns can represent many of the evolutionary phases of the building. The work was set in two stages. The first phase (chapters 1-3) consists of a bibliographic study on three main topics. An investigation has focused on (chapter 1) the evolution of documentation methods of the ancient egyptian monuments, from the antiquity until the contemporary period. The aim is to place this study in the current context of architectural research in Egypt and to identify the main methods for the survey on field. The second bibliographic study (chapter 2) analyzes the current knowledge on the construction aspects of the temples in the ramesside period. The last thematic study (chapter 3) deepens the current state of knowledge and studies on the temple of Antinoe. The second phase of the research (chapters 4 and 5) is a field survey. The work on the columns is divided into three progressive and complementary levels, combining the methods deemed most appropriate to the specific features of the temple complex. The first level is aimed at identifying homogeneous groups, by recording qualitative

and quantitative parameters, processed with typological and statistical analysis. In the second level, the stratigraphic method is applied to sample surfaces of the columns. The third level focuses on materials and techniques, with the management of the archaeometric available data and with laboratory analysis on samples of material. The results shed light on some basic steps of the construction history of the temple of Antinoe. At the same time there are some new questions and possible investigations on many aspects of the temple complex, to set several research directions. Reconnected to the existing knowledge on the temple, the field survey has produced results of considerable importance to clarify some aspects of the phases of construction, decoration and transformation. The main processes of construction and decoration have been identified on the various types of columns. In the courtyard, the same model of column was made in different ways (three types of assembly and two types of decoration), with a clear intent of the project. The traces of overlapping actions have been checked with the stratigraphic survey on the surfaces. The standard procedures of realization of the columns have been identified, often finding



1. West elevation of the entrance colonnade of the courtyard.



2. The two types of columns of the courtyard; decoration interventions post Ramesse II (red Merenptah, green Ramesse III, yellow Ramesse IX).



3. Cartouche with the name of Ramses II. Vertical stripe between two scenes.

specific solutions (insertion of blocks of stone, additions of varying thickness, removals, rework, repairs). The sequences of some stages of processing have been identified. It was also verified the replacement of some elements made after the collapses. The building materials have been identified quite clearly with macroscopic investigations and laboratory

analysis, focusing on the stones and their possible provenance. The study of mortars, much more varied, has been organized to assess the possible hypotheses on the mode of production and use. It revealed a production substantially related to the Ramesside phase of construction. There are two basic types of decoration in the columns

of the courtyard, applied differently to construction elements, confirming the action of different teams of builders and decorators. For decoration techniques, the micro-stratigraphic investigation integrated with laboratory analysis has given a preliminary framework quite clear. Some hypothesis have been proposed for the standard work procedures of the first Ramesside site and those related to the later pharaonic additions. The specific aspects of the materials used for the decoration (pigments, organic binders) were outlined with sufficient reliability. A remarkable accuracy of work was aimed at a homogeneous aesthetic result. The techniques are those of the traditional practices of the Ramesside period, with some variations for the later additions. The possibility of continuing this study could provide a perspective for new interpretations of this building. As well, the new directions of research can contribute to improve the knowledge of the temple architecture of the ramesside period.

ADMINISTRATION AND USE OF PUBLIC BUILDINGS IN MANTUA IN THE EIGHTEENTH AND PAOLO POZZO, PUBLIC ARCHITECT

Verena Frignani

The research deals with the management and execution of construction activities in public buildings in the former duchy of Mantua, in the century of the Habsburg rule.

The analysis of historiography of the city on eighteenth-century has revealed the presence of different types of writings and an increasing focus on economic and social aspects since the 50s of the twentieth century, when it began to support an analytical study of economic sources about properties to previous descriptions, which historical and literary approach. The interest of the Habsburgs for the territory and the urban core was tied to fiscal opportunities. On the quantitative knowledge of the acquired built heritage is established programs of reform the Habsburgs imposed during the entire century.

On the social level, it is evident the absence of a strong noble class who could take the opportunities of growth and change made by the new government; the aristocracy of the city derived its wealth primarily from rents, so showed no political capacity, no ambitions, nor appeared unable to confront with the emerging elite of officials that the Empire began to train. What takes shape is a photograph of the end of the Ancien Regime, with the necessary transition to a new

social and administrative status, a "modern" State, in which the case of Mantua, declassified in a few years from capital in little imperial province, is symbolic. Also the illuminist renewal of the city's buildings goes along with the directives of the best functionality, thrift, "decoration", of a "good government", especially in the bureaucracy, as in architecture. The function sets the rules of the building facade design, the ornate decoration and pomp are minimized, the rigorous lines communicate order and rational magnificence. They banned wastefulness and the useless luxury, but great weight is given to the possibility of reuse not only the built heritage available, but still material, objects, people (here is the reference for workers "trusted", but also administrators with multiple offices).

Compositional choices were heavily influenced by the presence of the new Academy of Sciences and Fine Arts, built by Maria Theresa in 1752, and his neo-classical orientation. The reorganization of the Academy and the incentives in the public education system promoted by the Habsburgs, were an other expression of a wider program of renewal, and new curricula were aimed at increasing the advantage of the State. It should be noted that the

interest of the Habsburgs for a real strategy on the buildings proved to be imminent just following the suppression of former convents and monasteries, in the second half of the century, when the substantial real estate assets which had become available to the *Regia Camera* was intended for public office. In this strategy, were reaffirmed values that put the State to serve the common good of all citizens, were enhanced the most functionality and administrative efficiency, the effectiveness of interventions, the need for economy and rejection of luxury, the development of a "decoration", moral and urban, which is expressed in the order. Architectures in Mantua have been extensively studied in many architectural aspects, but often were omitted purely concrete data, relative to the construction site, materials used, their supply and procurement. However, it's clear the necessity of a confrontation with this type of information, less "aulic", as representative of a single design implemented on all branches with the same objective. In this set of procedures, the executive operations, even the most humble and customary, corresponded to criteria dictated by a plant much deeper and broader, involving all spheres of the Habsburg state system,

the willingness of the Court, the administrative directives, guidelines for interventions to the buildings, until directions for the proper functioning of warehouses and public yards. This good organization of the State was governed from the bottom up, for example, those warehouses of building materials offering the possibility to store and reuse resources: wood, stone, lime, iron, etc.

The research focuses on the exploration of new sources, the potential that these - the archive of *Scalcheria* primarily - expresses and the objective the inquiry is aiming at. Archive data are processed to a specific treatment that describes the process of intervention on the public buildings: the decision-making phase, the competent organs, the design choices, the supply of materials, the execution of the payments. The prerogative of a research like this, that uses a fund large and internally differentiated, is the possibility of being open to multiple continuations and insights, both through an expansion in the acquisition of quantitative data and through a multidisciplinary discussion of the information collected. Buildings owned and operated by the *Regia Camera*, a sort of State property, is called *fabbriche camerale*. In the case of ownership of the former duchy passed under Hapsburg rule there is a significant two-fold distinction. The emperor, compared to Ferdinando Carlo, was not only the ruler against which the last Gonzaga was guilty of felony, but it was also his cousin and successor, so that the goods were confiscated in the imperial properties were

partly allodial property of which Charles V was heir. Moreover, in the former Duchy, the separation between ownership of the Gonzaga family and property of the city had never existed; allodial heritage and public buildings merged together in the Habsburg funds.

The management of this heritage was held the prerogative of the *Magistrato Camerale*, century old organ. To it, represented by the *Prefetti delle Acque* and *Periti camerale* (public technicians) was entrusted with the responsibility of building works construction, maintenance, demolition, including the process of organization and supervision of the yard. The description of the operation of the *Magistrato*, with the various tasks assigned to the *Questori*, management practices, reporting lines, positions and offices, has allowed to represent a specific theme, largely unexplored: the organization of the sector of public works in the Ancien Regime. In Mantua, it is interesting to note that this area only with the advance of the eighteenth century has assumed a gradual specificity. The very birth of the idea of a government property, finally divided by the personal assets, brought a substantial contribution to the activity of the public technician. The figure of the *Prefetto delle Acque*, always been linked to the hydraulic and infrastructural needs of the territory, gained increasing importance dealing with architectures and monuments: for example, Moscatelli and Borsotto realized several parochial churches, whose plan expressed the State control over

the Church, gradually increasing. The expansion of government powers, in addition to suppression of the monasteries, still increased the State property, introducing new categories of buildings and determining the rise in construction activity, primarily intended as reuse and maintenance. This also led to a more conscious separation of technical tasks and administrative decisions, namely to a greater definition of the duties of the figures involved procedure in the action on the buildings.

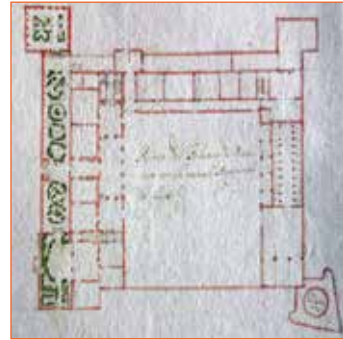
The figure of Paolo Pozzo, *Perito camerale*, but also architect and professor of the Academy, leads to many of the issues mentioned above, and well expresses the image of the new "official" at the service of the State, entered into an institutional and political mechanism which interprets and enhances the values. He is the conduit between State apparatus and Academy, not only because its excellent students are among the best executors and assistants in many construction sites, but also because he concretizes the strategy of public works used as a training tool.

LIVING IN MANTUA BETWEEN THE 16TH AND THE 18TH CENTURY: THE GONZAGA DI VESCOVATO

Giulio Girondi

The cadet line of the Gonzaga dynasty – originally called “*del Borgo*” from the location of the family palace in the “*contrada del Borgo*” – was born at the end of the 15th century with Giovanni, the third child of marquis Federico 1st and Margherita of Bavaria. Giovanni Gonzaga was born in 1474 and in 1491 married Laura Bentivoglio, one of the daughters of Giovanni 2nd lord of Bologna. Since his youth, Giovanni served his family as a courtier and held important diplomatic roles; however, he is now well known as a soldier rather than an ambassador. Giovanni served different Italian and foreign lords: the kings of Naples and France, the Emperor, the dukes of Milan and the Republic of Venice. In particular, the “*M[archio] A[rmiger]*” – as he called himself in his commemorative medals – served both Ludovico il Moro and Massimiliano Sforza during the two falls of the Duchy of Milan. Giovanni Gonzaga was even a patron. The first notice of his palace dates back to 1496. A letter between Giovanni and Duke Ercole d’Este of Ferrara testifies that the well-known artist Lazzaro Grimaldi worked inside Giovanni’s palace, decorating a room in 1502; perhaps a memory of these frescoes could be a fragment, recently attributed to Grimaldi, now housed in the Museum of

the Ducal Palace of Mantua. In addition to this, documents testify a strict relationship between Giovanni Gonzaga and the workshop of Lorenzo Costa. This palace was, perhaps, the biggest private house in Renaissance Mantua. Documents indicate the borders of the property and the general lay out of the plan, characterized by a main court with a loggia, two small courts and a garden, clearly recognizable in the *Urbis Mantuae Descriptio* (1596) by Gabriele Bertazzolo. The palace had a great hall at the first floor that Giovanni Gonzaga used not only for his own family, but even to set up comedies and to host court ceremonies: we should mention a great party in 1516, when the palace was furnished with leathers and tapestries belonging to the Duke of Urbino. Giovanni Gonzaga inherited the feud of Poggio Rusco in 1479; in the next years, the Duke of Milan Massimiliano Sforza awarded him the feuds of Piadena, Calvatone, Spineta, Belgioioso (1513) and Castelditone (1514), but Giovanni lost all these feuds after the fall of the Duchy of Milan. In 1519 Giovanni Gonzaga bought from the Gonzaga of Novellara the five-sixth of the feud of Vescovato, near Cremona. Giovanni Gonzaga died in 1523. His widow inherited the palace in Mantua, while his male sons randomly divided his other



1. The Rocca in Vescovato. The plan with “changes to do” drawn in 1690. (Archivio di Stato di Mantova, De Moll, b. 44).

properties. Sigismondo (born in 1499) inherited the feud of Vescovato, but he died only in 1530. His only male son, also called Sigismondo, was born in 1530; in 1546 he sold this feud to Emilia Gambara, a noblewoman from Brescia, but few years later he took action against her because in 1546 he was only sixteen. The “*lite grande*” ended at end of the 16th century when the Emperor declared Sigismondo 2nd sons (Carlo, Giordano, Guido Sforza, Fulvio and Francesco) lords of Vescovato. The *de facto* lordship of the Gambara was characterized by artistic patronage. For example, the parish church was adorned by frescoes by Malosso (now lost) and a new palace (also lost) was built near the church. In addition to this, even the rock was completely restored, as

testified by the main façade – which still shows late Renaissance eaves – and by the loggia in the courtyard, which was mentioned in an inventory dated 1583. Perhaps, even another inventory dated 1617 and a map drawn at the beginning of the 17th century describe the late Renaissance rock, before its baroque transformation fully explained by a drawing dated 1690 and by 18th century inventories. All the sons of Sigismondo 2nd lived together in the palace “*sul Borgo*” only for few years: this palace was lived in 1580 and in the next years Giordano and Carlo built new patrician residences. Fulvio and Guido Sforza remained in the family house up to 1602, when documents testify that the noblemen lived in the “*contrada*” of the Unicorn. In 1603 the duchess Margherita Gonzaga bought the palace to build the new convent of Saint Orsola (demolished in 1930). Guido Sforza perhaps lived in the house originally built by Andrea Mantegna (in the “*contrada*” of the Unicorn) that his son, Pirro Maria 1st, bought from Duke Vincenzo 1st in 1607. However, documents testify that Pirro Maria 1st lived not only in this palace, but even in the house of his mother-in-law Felicità Guerrieri Gonzaga in the “*contrada*” of the Bear. Pirro Maria 1st bought a palace near Felicità’s house, but when in 1611 she transferred into a new residence, Pirro Maria 1st came back to live in the house of Mantegna. In the next years, the nobleman completely transformed the Renaissance house into a baroque palace, but he lived here only for few years. Indeed, he transferred into

Felicità’s house when her son Luigi Gonzaga died in 1626. This palace was originally built by Giovanni Battista Guerrieri Gonzaga, secretary of Duke Vincent 1st, between 1597 and 1600. The palace is fully described in the *post mortem* inventory of the nobleman, drawn up in 1604. Scholars have attributed the architecture of the palace to the ducal “*prefetto*” Antonio Maria Viani, while documents testify that the interior decorations were executed by Orazio Lamberti, a collaborator of Viani. Moreover, a very strict relationship between Giovanni Battista Guerrieri Gonzaga and Antonio Maria Viani is documented: in particular, the nobleman, as a ducal secretary, had to control Viani’s work during the making of the new Ducal Apartment. Pirro Maria 1st Gonzaga was a very important courtier in Baroque Mantua: he was the ambassador who tried to legitimate, in front of the Emperor, the transition of the Duchy of Mantua from the Gonzaga dynasty to the Gonzaga Nevers line; but unfortunately Pirro Maria 1st died in Vienna in 1628. His *post mortem* inventory, drawn up in 1629, is a very useful document to understand his economical assets. The inventory mentioned properties inherited from the father-in-law of his father Guido Sforza in Veneto – the Campigli farm of Bettone, near Vicenza – and other goods properly of the Gonzaga di Vescovato: the house in the “*contrada*” of the Unicorn, bought by the gentleman in 1607 from the Duke Vincenzo 1st, the farm in the Te island (acquired by Pirro Maria 1st in 1622 from the Duke Ferdinando

Gonzaga), the farm at Tabellano (acquired by Guido Sforza, Pirro Maria’s father) and the “*corte di Porthiolo*”, with a “*palazzo da padrone*”. The farm of Portiolo was acquired in 1528 by Sigismondo 1st Gonzaga di Vescovato from the “*Prepositura*” of the monastery of San Benedetto in Polirone, then headed by Federico Gonzaga, Sigismondo’s uncle. Almost certainly, the farm had a mansion, as the Latin term “*viridarium*” (used to describe the garden in 1528) seems suggest. The house, characterized by a small tower mentioned in the inventory of 1567, was transformed into a “*palace*” at the end of the 16th century by Fulvio Gonzaga. In the next decades, new works were commissioned by Pirro Maria 1st, but his new palace remained unfinished because of the death of the nobleman, as testified by his *post mortem* inventory. Pirro Maria’s son, Ottavio 1st Gonzaga di Vescovato, completely transformed the mansion, building a new larger baroque palace. A letter by Ottavio 1st to Duke Carlo 2nd Gonzaga Nevers testifies that the architectural works began in 1661, while a letter by the painter Salvatore Castiglione – the brother of the well-known ducal artist Benedetto, called Greghetto – testifies that the “*bellissimo palazzo nuovamente eretto*” was almost completely finished in 1662, even if works for the baroque garden continued till 1700. The general lay-out of the palace is described by two watercolors drawn in 1690 for Pirro Maria 2nd, the son of Ottavio 1st, and by 18th century inventories.

FROM THE RULE OF THUMB TO THE BEGINNING OF STRUCTURAL MECHANICS IN FRANCE (1716-1841): THE CASE OF WOOD BRIDGES

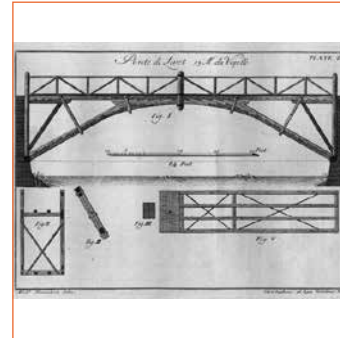
Chiara Tardini

The subject of the research is the analysis of the transition undergone between the 18th and the 19th century by structural design, passing from the traditional approach, based on heuristics, to the new scientifically based one. The focus is on wooden bridges, which provide a clear picture of the evolution in the design practice. Special attention has been conveyed on bridges, as representing an important structural typology, as well as on wood, a versatile building material widely utilized in bridge construction at the time. The work has been organized in three parts, which are directly reflected in the three chapters of the thesis.

In chapter 1 the selected documents describe the state of the art in the design of wooden bridges around the middle of the 18th century. Paragraph 1.1 presents early expressions of the need for a rational approach to design. Knowledge and practice typical of the time are well reflected in a selection of meaningful items from the French Encyclopaedia. In paragraphs 1.3 and 1.4, two manuscripts are presented, the discussion they present is about rules for an appropriate definition of the beam size. Paragraphs 1.5, 1.6 and 1.7 provide a comprehensive picture of the common practice in

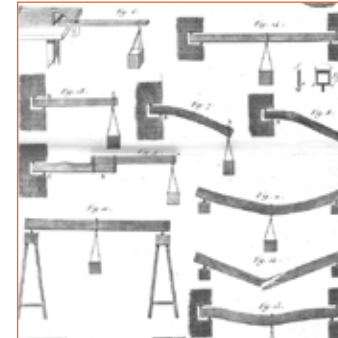
wooden bridge design in the 18th century; reference is made to the wood bridge design tests at the *École des Ponts e Chaussées*, to the Grubenmans works, and to Wiebeking's arch bridges. Chapter 2 is about the advances of the scientific knowledge in structural mechanics, as they can be found expressed in the French treatises written in the first half of the 19th century. The solution to the beam theory is the main subject. Due to the number of works on this topic, a selection criterion was adopted focusing on treatises where both the theoretical and experimental approach are present at the same time.

The procedure followed by Rondelet to find an "experimental solution" to Galileo's rule is mainly based on tests, and is not so far from the exact solution proposed by Navier. According to Rondelet the bending and the compressive behavior are strictly related to the tensile one. The contribution of Girard is in defining both the bending and compressive wood behavior. He carried out a quantity of tests on compressive behavior, the tests results were used to better define formulas to compute beam deflection in different conditions. The work of Hassenfratz is mainly related to tests that were carried out



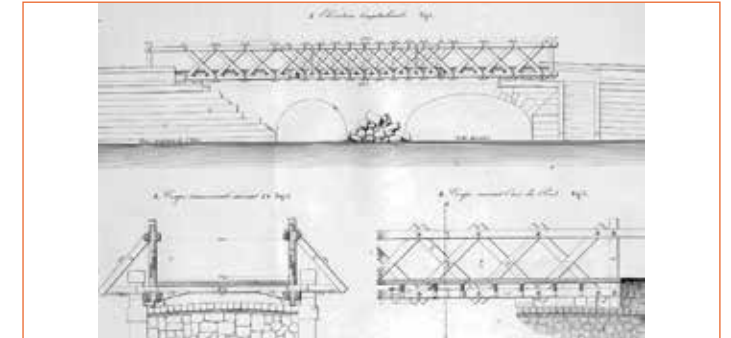
1. M. Shanahan, C. Dall'Acqua, *Ponte di Livet, 1775 - Early Works R.I.B.A. London.*

in order to put in evidence the influence of different kinds of loads and constraints. The results of the tests were collected in a great number of tables ready for practical use. The contribution of Gauthey's work is oriented to defining a formula that could describe the behavior of wood elements, describing the stress profile on the cross section of beams in flexure. Navier based his theory on experimental tests carried out by other investigators, but unlike Gauthey, he expressed different formulas: the rigorous analytical one and an approximated one that could be easier to use in practice. It was finally possible to apply this scientific approach in design practice. The first application of the formula of load bearing capacity as expressed by Navier is documented in chapter 3 and refers to Ithiel Town's wood bridges.



2. J. H. Hassenfratz, *Traité de l'art du charpentier, Planche 5, 1804.*

Chapter 3, finally, goes back to the theme of bridges with the presentation of Town's patent, which reflects the North American need for a systematic approach to design, in view of a large scale production of bridges. The Town lattice truss patent was granted in 1820. The aim of Ithiel Town was to define a cheap structure that could be widely adopted in the new and rapidly expanding railway system. At the meantime, the structure had to support heavy loads. In 1835 a new patent was granted, additional improvements were made. In both cases, the design approach of these structures was still based on empirical criteria. European engineers went to the United States to study and see these bridges; the report of their travel was translated and documented in the *Annales des Ponts et Chaussées*.



3. Vaudreuil temporary bridge, 1841.

The first documented uses of this patent in France are presented in the chapter. Three cases have been selected; they are the first documented application of the beam theory to the evaluation of a bridge load carrying capacity. Also the reference documents related to these cases come from the *Annales of the École des Ponts et Chaussées*. The conclusion of this research is well demonstrated by the above application, which shows the final step in the transition from the empirical approach to the new design practice. Numerical procedures according to Navier's bending theory were adopted. In these examples, although the element dimensions were not defined by this theory, the load bearing capacity was checked with it. In the spirit of Galileo's view,

the structural behavior could be both described and interpreted through numbers.