Structural damage prevention in the historical building site. Theory and praxis in the eighteenth century in Campania

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ABSTRACT: The contribution focuses the attention on the methods which have been adopted in the past in order to prevent masonries damages, with particular reference to the context of Campania during the XVII and XVIII centuries. The examination of contemporary building sites, united to that of the scientific contemporary production, wants to put in light, particularly, the connections between instructions contained in scientific essays and the operating praxis. Historically, the period is really significant because of the birth of the “restoration”, as modernly intended. The conclusions of the essay want to point out that the deepening of the static history of the buildings of the past should be particularly attentive to less striking aspects and should make use of archival and bibliographical sources. This can provide an useful contribution to the present project of preservation.

1 NEAPOLITAN STRUCTURAL TREATISES

1.1 Damage prevention: rules and regulations

A very specific chapter in the history of “building art”, could be found in the set of devices pursued, in the last three centuries, in order to prevent structural damages, during building stages.

Beside the “reinforcement history”, but different from it, this topic seems to be not known so well because of the lacking in bibliographical and archival documents about historical technics of “pre-reinforcement”. Expedients used in the past – chains, buttresses, lightening methods, etc. – were part of the building know-how, handed on by oral tradition.

Luciano Patetta, in 1990, although the long lasting tradition about these techniques, underlined the difficulties to distinguish the pre-reinforcement devices, even after an accurate view, because of the frequent replacements or considerable weathering, as well as the similar ways used by the reinforcement techniques after structural decay. Furthermore, Patetta showed some cases of Italian buildings, starting from Middle Ages, where the chains became elements of architectonic project, especially in “no tectonic” buildings where the shapes seem to overcome tectonic laws (Patetta 1990–1992).

Opposite to the habit usual to prevent structural damages since the beginning of architecture, several treatises hostile to this practice were written during the Renaissance. For example, Leon Battista Alberti urged to avoid pre-reinforced arches and proposed the use of “whole arches which do not need chain, because they are able to remain intact” (“archi interi non abbisognano di corda, poiché essi sono in grado di mantenersi intatti da sé”, L. B. Alberti 1485, libro III, cap. XIII).

In the same way of L. B. Alberti, Vignola, Palladio and Scamozzi exhorted to “avoid misuse and errors of putting iron and chains in the structures” (“fuggire quegli abusi, e disconci di mettere ferramenta e catene”, Scamozzi 1615, p. II).

The wood as well as the iron is mentioned in the treatises as a material for preventive measures; wood scaffolding, put inside the city walls, is shown in the first volume of the Vitruvio’s treatise and repeated by Palladio in the illustrations of the “Commentarii di Caio Giulio Cesare” (1575).

A building model spreading in the practice and “scientifically” known since XVIII century is the “framed” (“inteliata”) house, built with wood frames (Barucci 1990). A lot of space was given to this structural model in eighteenth century manuals, especially after the earthquake happened in Calabria in 1783. On that occasion, the most important scientific writings, conceived for something distant from the kingdom capital, were published in Napoli: Giovanni Vivenzio, History of earthquake of 1783 and what has been done until 1787 (“Istoria de tremuoti avvenuti nel 1783 e
The neapolitan architects Pompeo Schiantarelli and Ignazio Stile were the illustrators for Michele Sarconi’s “Atlante...”. Both of them worked at the rebuilding in Calabria.

As for the above mentioned works, “Technical rules...” (“Norme tecniche...”), written by Francesco Pignatelli in 1784, represent the first “anti-seismic” rules manual, addressed to Bourbon Court and to intelligentsia around it.

Those rules concerned width of the roads and buildings height; the construction of domes and bell towers was prohibited, while the use of building “baraccato” was exhorted.

In the 1784 rules, a special attention was given to devices for containment of vaults and ceilings drifts, to get by “iron bends to fasten every building in its parts” (“fasce di ferro da stringere ogni edificio in tutte le sue parti”, De Ioanna & Piccarreta 2000).

All of these works, published after earthquake events, follow the studies of Vincenzo Lamberti and Nicola Carletti, of whom the most important works concerning structural topics were written in the seventies and eighties of 1700.

1.2 The contribution of Vincenzo Lamberti and Nicola Carletti

Vincenzo Lamberti, author, in 1773, of the Right Vaultimetry (“Voltimetria retta...”) and, in 1781, of the Building Statics (“Statica degli edifici...”), testify, as Nicola Carletti and Vincenzo Ruffo do, the state of art at his time in matter of construction theory in the capital city of Bourbon kingdom. In his writings, as in the Institutions (“Istituzioni...”) by Carletti, it is possible to find the most direct scientific references for his contemporaries involved in practice. The Building Statics, particularly, seems to be the local translation of theories matured beyond the Alps in the first half of the century, joining theoretic rules and useful examples of practical application, through a rational organization of the matter.

Rather than consolidation problems, Lamberti’s works deal with the matter of building methods in new parts of the fabric, explaining general rules for their calculations. The last part of the Building Statics is particularly interesting, as the author dwells upon the possible causes of static troubles in buildings. “Weakness of foundations” (“Mancanza del pedamento”), “shaking” (“scuotimento”), excess of load supported, bad construction, antiquity and the different exposition of the building parts to the sun are quoted as the principal causes of static troubles of a fabric. For each one of these, with a rational approach to the problem, Lamberti fixed a corresponding type of cracking.

Although he did not deal specifically with the vaulted structure troubles, he explained the case of cracking in arches bearing a dome. His instance is a typical explanatory model for contemporary architects for connecting the troubles of the arches with the ones of the impending vaulted structure. The work of Vincenzo Lamberti does not provide a solution to the question, but he writes in the conclusions of his writing: “For building repairs the Architect must reinforce it with wood structures, in the void parts of the building, because there is no loss possible for separate parts; and then damaged structures have to be rebuilt, according to places and circumstances; all this depending by abilities and knowledges of a professor” (“Per la riparazione dell’edificio dee prima l’Architetto assicurarlo con cataste, e puntelli in quei luoghi, ove le parti dell’edificio han descritto spazio nell’aere,
o sia nell’ultime parti dell’edificio prive di ostacolo, poiché non vi può esser mancanza sotto le parti distaccate, come dalle dimostrate teorie si è dedotto; ed indi si debbon rifar le parti patite secondo le teorie esposte nella presente opera, adattandole a’ luoghi, alle circostanze, che concorrono, ed agli usi; dipendendo ciò dalla prudenza, accortezza, perspicacia, ed avvedutezza di un esperto e dotto professore”.

Carletti also afforded the study of domes (“volte a cupola”), dwelling several times with the risks of this kind of structures, “by nature light, imperfect, expensive and dangerous” (“di natura leggere, ed imperfecte; spesose, e pericolose”). The dome vaults are the results of a “joint of several pointed arches” (“concorso di più archi acuti”). Regarding their resistance to vertical stresses, the author made a difference between two types of structures: dome vaults and hemispherical vaults.

However, the question of intervening on existing buildings did not concerned the 18th century architect, who simply meant to “rebuild the ruined parts” (“rifar le parti patite”), according to the good rules of *ars aedificatoria*.

## 2 VAULTS PRE-REINFORCEMENTS IN NAPLES

### 2.1 Advances in neapolitan historical building site

The direct knowledge of local structural theories and that of damage causes provided useful information to Campanian architects in order to avoid similar problems in designing new buildings.

Structures lightening, drifts control, masonries portion were pursued in restoration and, in parallel, in new constructions.

It is possible to identify some examples of pre-reinforcement techniques both recurring to *in situ* exploration and, partially, from archival documentation. Especially regarding vaults, the recourse to hoop-iron bonds in neapolitan building sites spreads with evidence at the end of XVII century and in consequence of damages due to the earthquakes happened in 1688 and 1694.

Two significant cases can be considered the domes of the churches of St. Charles in Arena and St. George the Greater; in the first case, the architect Arcangelo Guglielmelli planned, in 1694, to encircle the dome and its lantern with an iron chain (Amirante 2000). The same architect planned, five years later, the enthainment, during the construction, of the lantern of St. George the Greater dome (Amirante 2000).

Significant advances of pre-reinforcement can be identified in two important historical structures in Naples: the domes of the Treasure of St. Gennaro’s Chapel (Savarese 1986) and that of the church of Holy Mount of Mercy. The first one, erected between 1608 and 1618, is composed of two calottes in order to reach the height of one hundred meters from ground floor. The dome, with its tuff masonry, is constituted of a windowed drum, regularly marked by piperno volutes. It is interesting focusing that, during the building process, the external calotte was connected to the internal one by eight buttresses and an internal lantern, replaced, because of its weight, by a lighter wooden pinnacle (ATSG, DA/9). The described structure was pre-reinforced, during the erection, with an iron chain at the top of the drum: Nicola dello Mastro, blacksmith, was paid in 1612 for going to Avellino in order to buy iron for the chain (ATSG, DA/8). Similarly, Francesco Antonio Picchiatti enchained in 1660 the Holy Mount of Mercy dome with a double hoop-iron bond, made up of eight elements. The lantern was provided of a hoop-iron bond which connected masonry elements and pre-reinforced the top of the structure.

### 2.2 Mario Gioffredo and the pre-reinforcement of the Holy Spirit dome

The reconstruction of the dome of the Holy Spirit basilica, planned by the royal architect Mario Gioffredo, can be explanatory of the technical and
scientific knowledge reached in XVIII century in Naples.

The structure, started in 1768, presents a circular plan with an internal diameter of fifteen meters and an external one of eighteen meters. The drum upon the base is seven meters high and it is marked by columns among the windows. It is followed by the “attic”, the vault and, finally, the lantern, surrounded by a balustrade and concluded by a groined little cupola.

Many archival documents, subscribed by Gioffredo, clear up the structural planning of the dome and illuminate on the technical aptitude of the royal architect (ASNa, Opere Pie-Spirito Santo, ff. 49-50). Gioffredo’s competence results, particularly, from the methods adopted for lightening the dome vault (11 meters high); the architect used masonry in the vertical part and the first half of the curved one and had recourse to the very light pumice stone for the last five meters of the vault. Similarly, the groins were constructed with a “mixed” method related to materials’ weight: the first part of them is made of bricks, the middle one of tuff and the last one, on the top, of pumice stone.

Mindful of the structural damages due to past earthquakes, Gioffredo supported masonries with a complex system of tie-beams. As archival documents show, iron was worked in order to realize two tie-beams for the choir’s arch; moreover, they were placed on the windows of the drum, on the choir’s vault, on the bell tower windows and even under piperno thresholds of the same windows. The dome was enchaigned at the middle of its height and the “attic” at the base was enchaigned, too. Tie-beams were put on the drum windows and into the staircase existing into the same drum. The four pendentives were braked with iron while the four dome’s arches were pre-reinforced with tie-beams. The connection between the dome and the external walls of the transept was ensured by four couples of tie beams, placed in parallel with transept long walls (ASNa, Opere Pie-Spirito Santo, ff. 48-49-50).

Finally the structural dome’s elegance was confirmed by the lantern’s constructive modalities (ASNa, Opere Pie-Spirito Santo, f. 50). Aims as structure’s lightening and drifts’ reduction were reached by the recourse to wood for the top cupola and to iron tie beams. The first one was realized with the association of two buds made of oak and chestnut; the first convex bud was obtained by the connection of twelve radiate ribs in correspondence with the groins below. Above this bud, Mario Gioffredo planned another wooden element, constituted by 34 chestnut blocks, externally shaped.
As in dome below, the royal architect joined, in the lantern, an intelligent use of iron in order to absorb forces and connect the different parts. Two hoop-iron bonds were put at the base and at the upper part of lantern’s drum; the structure was pre-reinforced by them and by transversal iron bars, necessary to maintain the cross at the top.

The plan of Gioffredo, well known rival of Luigi Vanvitelli in Royal Palace of Caserta, was especially praised by the neapolitan technical entourage, as many archival relations demonstrate. Among them, we can distinguish the agreement of the royal architects Giuseppe Astarita and Giovanni del Gaiso who, foreseeing the building future, praised Gioffredo for the adopted structural methods.

3 CONCLUSIONS

The mentioned cases provide a significant example of the importance of an in-depth historical study before any preservation programme. In fact, the only direct inspection does not enable to recognize complex solutions adopted in the past in order to ensure the stability of structures; bibliographical and archival sources can provide useful information about materials provenance, details on working techniques and on specific pre-reinforcement or consolidation methods.

This kind of information make part of a "building art" oral tradition which does not emerge from "official" treatises. In any case, the knowledge of these latter is absolutely essential for the comprehension of the scientific progress in a particular geographical context and historical period.

Moreover, structural treatises can furnish useful information about the knowledges which architects of the past should have acquired in order to plan their structures.

The interrelation between in situ inspection and historical investigation helps to distinguish the specific solutions which have been adopted. Archival sources, often consisting of technical relations or advices, tenders, calculations, can form a solid base for a diagnostic programme, too. For instance, the forecast of invisible iron elements, just described in historical documents, can address magnetometric tests.
Similarly, the historical identification of “enlightened” or, on the contrary, reinforced parts helps to exactly localize “weak points” of the structure in the present.

Some more considerations can be done in relation to the conservation programme. An in-depth historical study must bring to the preservation of formal and aesthetic aspects of the building and, especially, to the preservation of historical and constructive values. It is possible to preserve a complex structural conception only recurring to the careful knowledge of the building techniques and to that of all the adjustments, “corrections”, transformations made in the past. These latter ones can be correctly distinguished by “pre-reinforcement” expedients only recurring to historical sources; moreover, their presence or absence in the analysed structure can prove pre-reinforcements’ ineffectiveness or their efficacy, respectively.

A peculiarity of a preservation programme is its “complexity”; it can be obtained only as the result of an interdisciplinary elaboration in which history and technology talk to each other.

REFERENCES


Lamberti, V. 1781. Statica degli edifici in cui si espongono i precetti teorici pratici, che si debbono osservare nella costruzione degli edifici per la durata di essi. Napoli: Giuseppe Campo.


Seamozzi, V. 1615. L’idea dell’architettura universale. Venezia.


ASNa = Archivio di Stato di Napoli.

ATSG = Archivio Tesoro di San Gennaro.

APM = Archivio Pio Monte della Misericordia

Gianluigi de Martino has written par. 1.1 and 1.2 while Valentina Russo has written par. 2.1 and 2.2. Both of the authors have written par. 2.3 and 2.4.