Endoscopic Analysis Supporting Issues of Historic Stratigraphic Investigations: the Case History of Saint Domenico Monastery in Naples-Italy

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Abstract
The Saint Domenico Maggiore Monastery in Napoli-Italy is largest monumental complex of city and its constructive history, with its articulated stratigraphy and its valuable artistic heritage, renders it one of most relevant monumental site of this great historical city. In occasion of a long a difficult intervention or conservative restoration, started ten years ago and yet to conclude, the monument was object of a different kind of activities aimed to its knowledge, consisting above all in analysis of historical and stratigraphic kind, but also diagnostic investigations. In some cases these two categories of analysis were integrated or superposed, especially to understand really complicated issues. The Saint Domenico Maggiore Monastery, constructed on a first little chapel realized in VIII century, had a first great intervention of enlarging in XI century, but it is possible to recognize at least nine great transforming phases, realized both for functional needs and after severe earthquakes. In this context this contribution regards a specific experience, which can evidence how diagnostic investigation, in this specific case endoscopies, were able to represent an element of implementation of technic and constructive knowledge and how these information were useful both to help stratigraphic and historical comprehension of a most complicated part of monastery, the Saint Domenico’s cloister and its large staircase. In fact capability to verify directly technological characteristics of every masonry pilaster of cloister (tufa, bricks, tufa and bricks) with an easy, but micro-invasive investigation, permitted to correlate different arms of cloister to different constructive phases, giving elements useful in phase of numerical evaluation of seismic performance of this structural part in comparison with buildings of monastery distributed around the Saint Domenico’s cloister, with a consequent significant reduction of restorative project. This case history, simple in its content, but interesting in terms of strategy and approach, is inspired by a cultural orientation, based on interdisciplinary, permitting a holistic vision, born through interconnection of some point of views, able to reduce evaluation mistakes and consequently to improve and verify every project choice.

Keywords: endoscopy, historic investigation, Naples

1. Introduction
The complex of San Domenico Maggiore is the largest monastery in Naples, important city of Southern Italy and UNESCO World Heritage Site. The complex is very important not only for value of its architecture and artistic objects, but also for a very interesting and complicated construction history, summarized below, in order to highlight the difficulty of knowledge of its stratification and how the execution a dense endoscopic investigation might have contributed to clarify unknown aspects (Fig. 1).
- Phase I: original foundation, VIII-X century. The reading of historical documents shows that the original foundation, relating to a period between the VIII-X century, had to be very articulate and it was largely preserved in the deep transformations of the XIII century. However, there are not, in the present configuration, large portions attributable to this period. 
- Phase II: the XIII century. The bibliographical sources have led to attribute to this second phase (1283-1320 approx.), following portions of current configuration of the Monastery: the Church of Saint Domenico Maggiore, the Dormitory of Saint Thomas (two floors), the Master Dormitory (two floors). These new buildings were connected to those pertaining to the first phase and not object of demolition; so, reading the complicated plan of the complex, emerges that it in this period had already occupied much of the available lot, so as to arrive to occupy its limits, bordering the roads and surrounding private buildings.
- Phase III: the XV-XVI century. The fact that already in the XIII century the available land of the lot was mostly occupied by monastic buildings meant that in the later phases it was not possible the construction of new buildings, but only three kinds of intervention: the first was aimed to make enlargement (like the new novitiate); the second to occupy little free spaces with duplication of volumes (for example the porch beside the Master building), projected to optimize the use of a residual open spaces; the third to operate a reconfiguration of existing volumes (like in the case of the Saint Thomas’ cloister and its north-east part, built on an old road inside the insula, making a new wing for monastery, also demolishing many small private houses).

- Phase IV: the XVII century. The fourth phase is an important step in the history of the monastery, taking the shape and the formal configuration which still today characterizes it, being this the last phase in which war realized a not sporadic and occasional reorganization, as it will happen later, but an extended and generalized change. Like during the third phase, in this occasion the lack of free spaces in the lot put in the need for increased the urban density of the lot, with choices homologous to those showed for the third phase. In fact, even in this period was chosen to proceed with an occupation of empty spaces (realization of the upper level for the San Domenico’s cloister) or with a duplication of volumes (construction of the cloister for the St. Thomas’ dormitory) or with some new elevations (like the third floor for the Masters building and for the St. Thomas’ cloister and like the second floor of the novitiate) or finally with creation of little enlargement (like new entrances) located in two of few areas not yet built.

- Phase V: the XVIII century. The interventions of the XVIII century cannot be realized inside the lot, now heavily saturated, so they chose to build in an area located near north limit of this lot, with occupation of little houses, producing a narrowing of road, which becomes a narrow alley. In this new part were hosted in fact mainly warehouses and primarily the great staircase for the Saint Domenico’s Cloister [1-2-3].
1.2. The Saint Domenico’s cloister

The Saint Domenico’s cloister is a key element for a better stratigraphic knowledge of Monastery, for this reason it has been the subject of a specific analysis, which led to concentrate in this area an intensive endoscopic investigation, referred to below.

The cloister of San Domenico was built during the fourth phase in the XVIII century, but probably in more steps (Fig. 2). The literature suggests that during a first step, between 1669 and 1673, were mainly carried out intervention aimed to define an internal reconfiguration of existing rooms (renovation of the infirmary rooms to change them in a refectory, reuse of Chapter positioned over the Saint Thomas’ room, the reorganization of rooms ranging from the buildings pertaining the courtyard, in alignment with the Saint Domenico’s cloister, to the first half of the Master dormitory and Saint Peter’s in Maiella alley, and finally to the Pronaos of main facade of Church) and only later, between 1678 and 1682, new buildings were realized (third floor of the Saint Thomas’ dormitory, the third floor of the Saint Domenico’s dormitory, the second floor of the novitiate, entrance hall with the library above).

So during the first phase, the Saint Domenico’s cloister could not be achieved on all four wings, because there was not still the building of library; probably between 1669 and 1673 were made only two wings to the east and north, so to connect the area to the west (which housed the two dormitories) and the parts just reconfigured the east (which housed the chapter room and refectory room, refitted at this stage), followed by the west wing. That is why the pillars of these three wings show homologous constructive characteristics.

During the second step of this fourth phase, between 1678 and 1682, is built a new entrance with above a new library, presumably realizing completion of the cloister, adding an arcade also for the south wing.

Supporting this hypothesis, in addition to a use of different constructive techniques of pillars, there are some elements: - the south wall of new library was built thickening the wall that enclosed the Saint Thomas’ cloister, pertaining to the third phase (XVI century); - the north wall of library is not connected with its orthogonal walls; - in the library the entrance from the north is different from each other: the first in the east (which probably was the only access to be placed on the originating east wing of the cloister) has regular lintels, built with brick and tuff; the other entrance instead is smaller and irregular, so it could be opened after the completion of the fourth wing of the cloister; - always the north wall has some windows, then closed, which do not appear to be false windows, in fact their shapes are well done also in the wall which overlooks the cloister [4-5].

Figure 2. Saint Domenico’s cloister, today (on the left) and in the XIX century (on the right)
2. Diagnostic Investigation

Considering the importance of the Saint Domenico’s Cloister in determining the history of this monument, it is willing to deepen in this area the majority of diagnostic tests. This activity is part of the long and complex conservative restoration of monumental complex of San Domenico Maggiore, representing also an opportunity for a direct verification, though still partial, of articulated stratification of this architectural monument; this has been made possible above all through execution of a series of activities such as inspections and controlled demolition, always strictly kept to a minimum, evidencing elements able to are a support for the reconstruction of the history of this building and sometimes unknown to large bibliography and documentation sources, which for this monument are extremely numerous, but also partial, adversarial and sometimes misleading. These findings, almost never accidental, are the result of a severe search, of a systematic reading of historic sources, including some unpublished, of a constant, observation and investigation of building and of execution of extensive diagnostic tests. The Monastery of San Domenico Maggiore has been subject to a set of diagnostic instrumental investigations both in a first phase, aimed to optimize the intervention project, and in a second phase, during liberation, controlled demolition, etc., activities, highlighting situations and circumstances able to obtain a better general and historic knowledge. In fact these investigations were carried out in support of technical and structural evaluations, useful for structural conservation project, as well as for understanding its phases of construction. So the endoscopic investigations at the Saint Domenico’s cloister are a part of this of knowledge program [6-7-8-9].

2.1. Endoscopic analysis

Endoscopic technique allows you to observe, inspect and document masonry panels in their section and generally hidden portions of structures. Endoscopy can be applied for a lot of different uses: documentation of structural elements (walls, floors, vaults) in order to investigate their materials, techniques and construction phases; analysis of degradation and instability (moisture, cracks); evaluation of effectiveness of intervention in progress (for example during consolidation operations with injections it is possible to value paths of injected material and reporting formation of accumulations and deformations). However, endoscopy requires execution of a small hole, it is therefore a micro-invasive test, but sometimes it provides detailed and reliable information difficulty to obtain using other techniques, especially if non-invasive. In this study case the diagnostic investigation project was very extensive, in fact it provided for tests in each pillar of Saint Domenico’s cloister at the ground and first floor (Fig. 3), with execution of a couple of endoscopies in two orthogonal directions, positioned at a height of 70 cm and 150 cm from ground (Fig. 4).

Figure 3. Localization on endoscopies: 0 level (left), 1 level (middle) and scheme of realization (right)
2.2. Endoscopic results

The results of endoscopic investigations, carried out before with an inspective mirror, and after, to observe details, using a diameter. 14 mm modular rigid endoscope with variable prism and monocle zoom, has led to highlight, using the visual analysis and reading of endoscopies, the elements listed below.

The pillars of the main staircase and of cloister, pertain to four different constructive typologies: eastern-most pillar is realized with large brick (red),-the second pillar is built with brick masonry and it is characterized by use of very low bricks, also used to create the cover for the north wall of staircase (yellow)-the other pillars of main staircase rather are built with tuff and bricks (blue);-the remaining pillars of the cloister are realized only with tuff (blue).

It is possible that the different texture of these pillars is due to different function of pillars, in fact, those built with tuff (blue) must also support load of staircase ramp, unlike the first two pillars (yellow and red), which support only the above wall. There has, however, came to the understanding of why these two brick pillars were built with so different sizes (Fig. 5). It is clear, however, a stratigraphic correlation with a staircase, now no longer existing, and probably located at the back wall (Figs. 6 and 7).

From this technological classification of pillars of the cloister and of the staircase finally emerges that there is convergence between the typological characteristics of the staircase and the pillars, highlighting that they refer to the same phase (XVIII century), but were built in different steps of construction (1669 and 1678). The large number of investigations and the need to correlate the findings each other has led to propose a stratigraphic synthesis of results of every endoscopy, which has been very useful in interpreting phase of qualitative and quantitative data [10-11].
Figure 6. Endoscopic results, 0 level
Figure 7. Endoscopic results, 1 level
3. Conclusions

This dense diagnostic program shows that, if on the one hand historical knowledge of particularly articulated monuments often cannot be solved only in terms of direct investigation and documentation, on the other hand the minimization of invasive diagnostic tests, however, can be obtained only through a severe analysis history, where the instrumental diagnostics is not only a support for structural issues and it is effective if it is seen as one of the many steps of complicated process, which sees also in restoration project of monument an opportunity for its knowledge [12-13-14-15].

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