

Palazzo Cittadini-Stampa: role of stratigraphy and cinematic analysis in the knowledge of a masonry building

S. Bortolotto, C. Colla, D. Mirandola & A. Sponchioni

Politecnico di Milano, Milan, Italy

ABSTRACT: The Cittadini-Stampa building is a 18th Century cultural heritage, whose abandon has caused its extreme decay. To approach correctly the building's heritage and material, the present work underlines the role of stratigraphy and cinematic analysis as preliminary knowledge phases. The survey of the superimpositions due to historic developments of this masonry building, and of the crack pattern which has developed, lead to evaluate the static equilibrium and to give indications for the strengthening intervention. A multidisciplinary analysis has defined the structural characteristics and precarious points of the construction. Careful inspections, survey and diagnostic investigations have served as essential tool to highlight the crack pattern, active and possible cinematic mechanisms and other specific vulnerability of this building, an aggregate of not-coeval structures. The knowledge gathered has supplied indications to formulate a targeted project of structural improvement.

1 INTRODUCTION

The Palazzo Cittadini-Stampa is located in Castelletto di Abbiategrasso, within the western district-belt of Milan, along the Naviglio Grande, an artificial water channel of historical importance. It is a brick masonry, three-storey, rectangular-plan building, dating back

to the 18th Century (Figs 1–2). The northern front is plastered over and has a wrought-iron balcony and a wide, arched entrance. The windows have simple cornices and architectural framings which create a symmetrical central-axed rhythm throughout. The same architectural elements have also been used in the western and southern façades. The latter has



Figure 1. Palazzo Cittadini Stampa, main elevation on the Naviglio Grande, in a photo of the '80s.

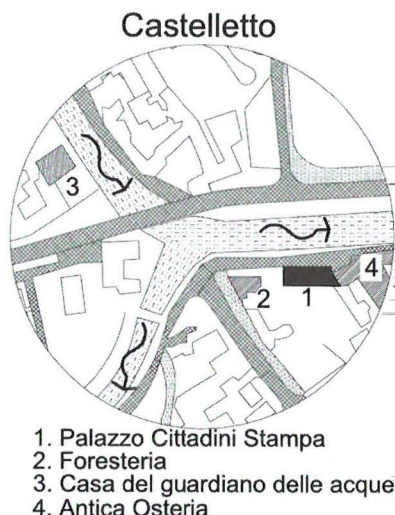
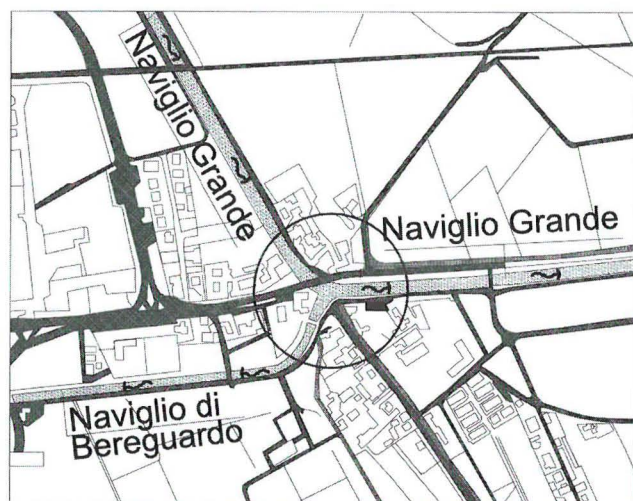


Figure 2. The building settings in the present territorial context, at the meeting point of the artificial water channels of Naviglio Grande and Naviglio di Bereguardo (left); the relevant buildings in Castelletto with historical connections to the Cittadini-Stampa building (right).

a three-span portico and a wrought-iron balcony on the first floor. Interiors are partly frescoed and have coffered timber ceilings; the stone stairs have elaborate wrought-iron handrails.

Since 1915 the building has been included in the list of historical buildings (*ex lege* 364/1909) and was hence legally under State's protection, which was renewed 1950 (*ex lege* 1089/1939). In January 1980, local authorities through the commune's Technical Office started to take urgent measures for the preservation and maintenance of the building and financed works to replace the roofing and to consolidate the ceilings; the works were partially carried out in 1982. The building, a communal property, shows heavy signs of material and structural decay. Along the years it has been stripped of most of its most valuable decorative elements: fireplaces, stone cornices and terracotta floor tiles. In 2003, the "Laboratory of Diagnostic for the Preservation and Re-use of Buildings" operating within the Department of Architectural Planning at Milan's Polytechnic University made an agreement with the local authorities to set up an on-site workshop for students in the Cittadini-Stampa building. The workshop became part of a post-graduate training course for "Experts in survey and diagnostic techniques applied to historical buildings" which was held in January–June 2003 (see note 1).

The course was aimed at training professionals working on historical buildings and focused on the following aspects:

- study of historical records and cartography (Figs 3–4);
- analysis of construction techniques and materials;

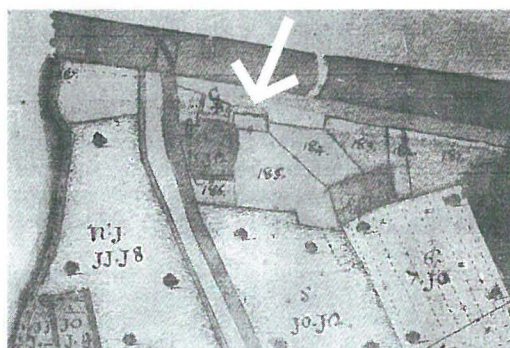


Figure 3. Portion of the Theresian Cadastre of 1751 showing the building on parcel number 185.



Figure 4. Detail of a fresco in the tower room at the first floor: ideal image of a XVII century palace.

- survey and elaboration of thematic maps (on paper and multimedia);
- diagnostic analysis (see note 2);
- preparation of analytical tables for preservation and re-use guidelines (see note 3).

Each course unit included practice within the on-site workshop, so as to gain direct experience of the complexity of analytical procedure and data analysis, preliminary steps to the drawing of any preservation project.

In July 2003, the Lombardy Region – together with Milan's Università degli Studi, Comune di Abbiategrasso, Milan's Province, Agenzia del Demanio (State property agency) and Aler (Lombardy Agency for Popular Housing) – signed an "agreement-plan" to locate some research laboratories, university and congress halls and one innovative museum in a number of historical buildings in Abbiategrasso. Accordingly, the Palazzo Cittadini-Stampa will house the "Water Museum".

The present study focuses on the evolution and structural analyses of this historic masonry building, and specifically on material "additions" and "subtractions", crack patterns and related "critical areas" (i.e. structural or potential weaknesses), which the preservation intervention will have to take care of.

2 STRATIGRAPHIC ANALYSIS

Intervention on historical architecture implies prior gathering of adequate information to describe the building in its geometric, morphological and material complexity.

Following this approach, the activities carried out on site started with geometric survey (see note 4) and then focused on various aspects: interpretation of the different construction phases of the building through stratigraphic analysis of the masonry walls, identification of the materials, analysis of present and past decay phenomena, crack patterns. The information gathered on site was integrated by stratigraphy survey in order to identify and understand the different construction phases. It has been ascertained that scientific methodologies borrowed from archaeological analysis can provide valuable results also in the field of architecture. This applied visual methodology favours direct observation of the source of interest, that is, reading off information from the walls themselves. It also contributes to in-depth study of specific aspects and suggests best practices to avoid irreversible loss of the genuine quality of the building and to preserve its multi-layered material history (Bortolotto 2004).

Stratigraphy analysis is a graphic methodology which allows to record layered construction phases which can be detected in a building. The archaeologist/architect's job is to reconstruct the chronological

sequence along with the material and structural decay process. The current debate on the relationship between archaeology, architectural archaeology and architectural restoration focuses precisely on codifying procedures to identify building processes and phases. To guarantee proper and efficient planning of preservation measures these must necessarily take into account all data deriving from the study of structural and material decay.

In the case of the Palazzo Cittadini-Stampa, only a limited amount of stratigraphy information could be obtained through visual observation (Mannoni 1984) due to the fact that the masonry patterns, the wall textures and toothing are largely not visible. In fact, the building is plastered on the outside and the rooms are plastered and largely covered by frescoes. Therefore, the procedure has been carried out where possible, non-invasively, and it granted detecting a sequence of building phases, as well as providing some structural indications of the construction. As a matter of fact, the static behaviour of the building has been affected by several additions which were made to the original core-structure.

Theoretical and methodological knowledge acquired during the study course has later permitted on site to acquire direct experience and to unveil several superimposing phases in the Palazzo Cittadini-Stampa. These stages have been ordered in a sequence which has disclosed the process of change and development that the building has undergone in the centuries. The study of the discontinuities in the masonry and of the many walled-up doors (revealed also through oblique-light observation), as well as the analysis of wall textures (with the help of active thermography), and above all the possibility to gain access to the garrets (where exterior elevations, plastered and painted, were discerned) permitted to detect the following main construction phases:

- a tower-house in the north-western portion of the present building. The "house" consisted solely of a ground-floor and reached as far as the present entry-hall, whilst the quadrangular "tower" had two storeys above the ground level. Two of its corners are still detectable in the North front and in the longitudinal spine bearing wall of the present building. On the top floor – which now corresponds to a garret – the tower had a projecting brick decoration, probably a windowsill for pigeons (Fig. 6);
- a "rectangular" body to the East of the tower-house, whose pristine South-front windows were walled up when the present Palazzo was built but are still visible in the garret, as well as parts of the corresponding plastered masonry wall;
- later additions to the above mentioned older structures, belonging to the present Palazzo Cittadini-Stampa. These are detectable through a number of elements: the absence of "toothings" or continuity

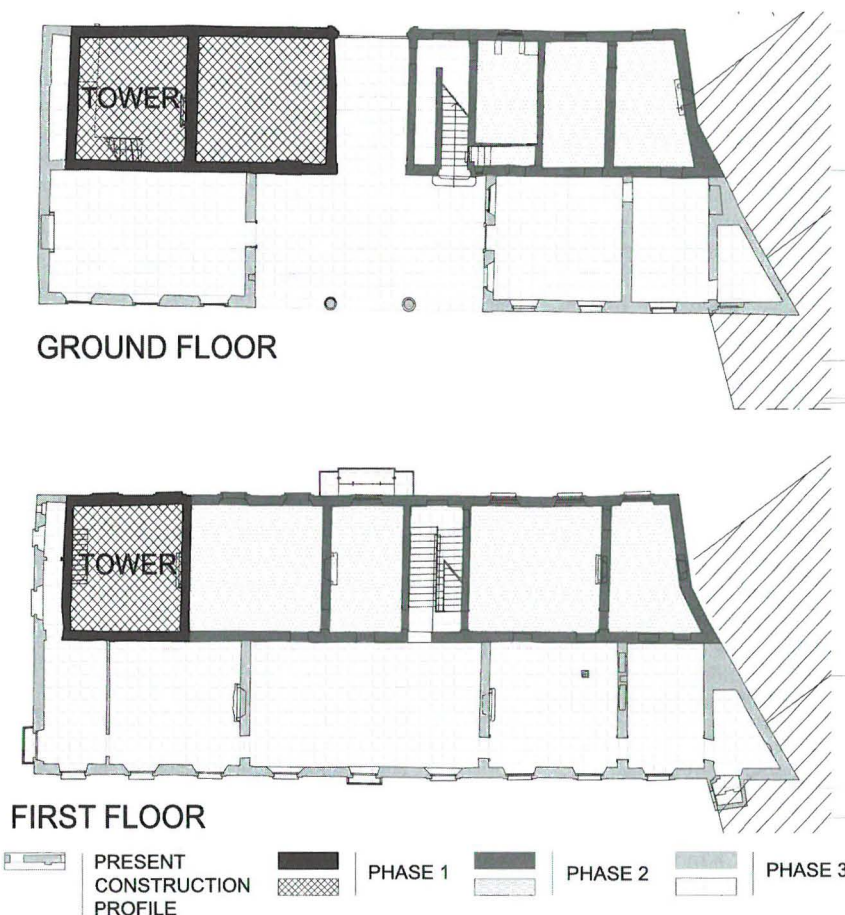


Figure 5. Building evolution as dated from its historic masonry.

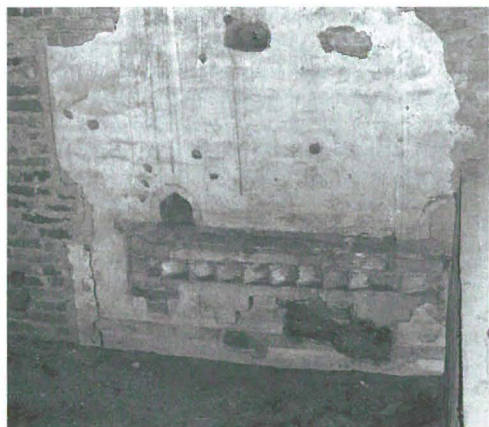


Figure 6. External projecting brick decoration of the ancient tower (visible in the garret of the present building).

between the newer and older masonry; alterations to the inner side of the tower's northern wall due to the opening of a window (on the first floor), which was meant to follow the new "rhythm" in the openings of the Palazzo itself; functional changes due to the construction of a new annex at north-west, housing secondary stairs, and a new grand staircase built on the previous flights but in a different way.

The main data have been summed up through simplified graphic schemes showing the different construction phases (Fig. 5).

3 STRUCTURAL DECAY ASSESSMENT

Through direct inspection of the site, a number of crack patterns have been described, which can be distinguished in passing-through cracks, non-passing cracks



Figure 7. Crack pattern of the main elevation (North) overlapped to that of the inner façade with projection of bracing walls.



Figure 8. Crack running vertically at the corner between bracing wall and longitudinal wall in the staircase.



Figure 9. Vista of the left portion of the North elevation with spalling of wall.

and some fissures which actually appear to be flaws in the plastering (i.e. several craquelure-like patterns in the coating). The most relevant fissure pattern involves the north-front external masonry. A visual survey of the crack pattern in this portion of the building

has been carried out along with a specular one on the inside of the same wall. The graphical output from both sides have been overlapped to obtain a more complete interpretation of discontinuities and structural damage (Fig. 7). Some axonometric projections are also

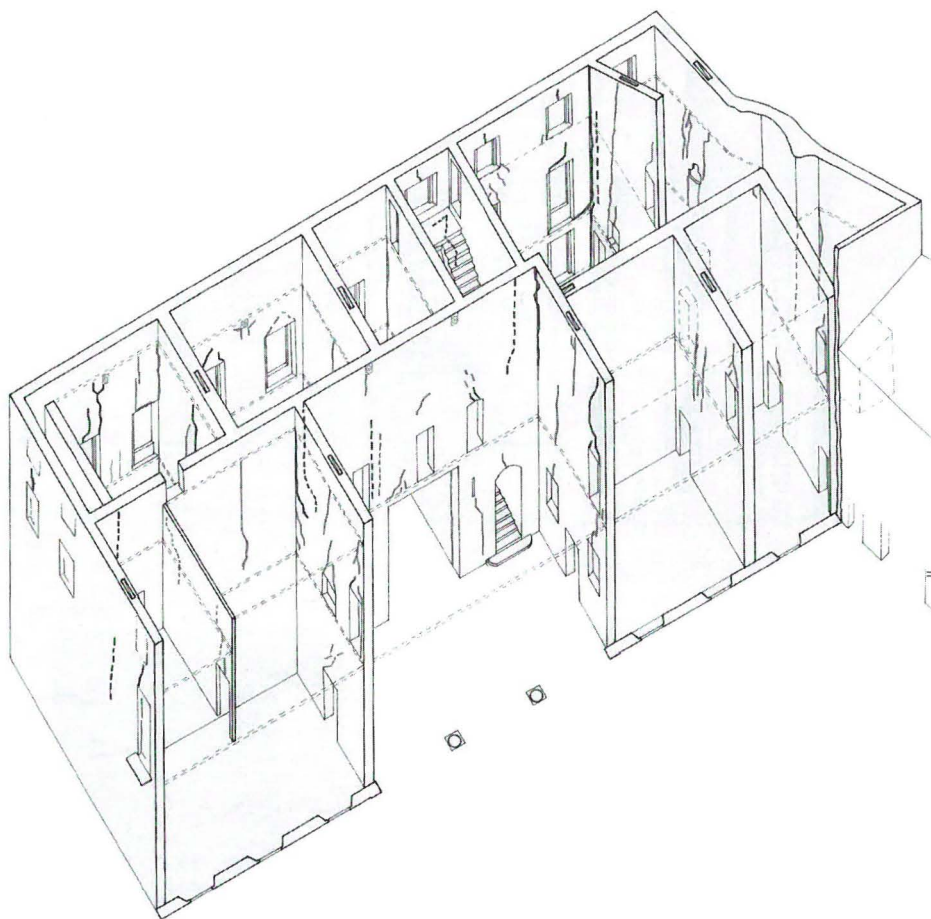


Figure 10. Axonometric projection of the crack pattern.

represented in Figures 10 and 11. As a result of this procedure and way of crack plotting, a three-dimensional reading of the decay phenomena in the building could be modelled and hence compared with the results of stratigraphy analysis in order to spot all "critical areas". Indeed the results from both disciplines may be combined to enhance interpretation.

One essential step has been the identification of the original core-structure of the tower-house within the present building. This construction probably dates back to the 15th century and shows fair stability due to its "box-like" structural behaviour, and well-toothed coeval masonries.

The structure which was built to the East of the tower-house during the second construction phase, has undergone later major redesigning, especially when the Cittadini-Stampa family chose to enlarge and renovate the Palazzo. It is precisely in this portion of the building – which includes the new entry-hall to the

porch and the new grand staircase – that the heaviest structural problems have been discovered.

The third and last main construction phase involved both the "doubling" of the Palazzo through a "mirror" development to the South (its bracing walls abut against the longitudinal bearing wall) and the addition of a new portion to the west, leaning onto the first phase structure.

In order to attain consistency and unity with the pre-existing architecture and to increase functionality according to the owner's new requirements, some partial or extensive demolitions were carried out in this last phase with the aim to improve inner communication through new stairs and new doors which were opened into the old bearing walls. To this phase also belongs the reorganization of the house main infrastructural services, in particular the heating system.

Discontinuities caused by the construction of new chimneys are easily detectable on the older walls.

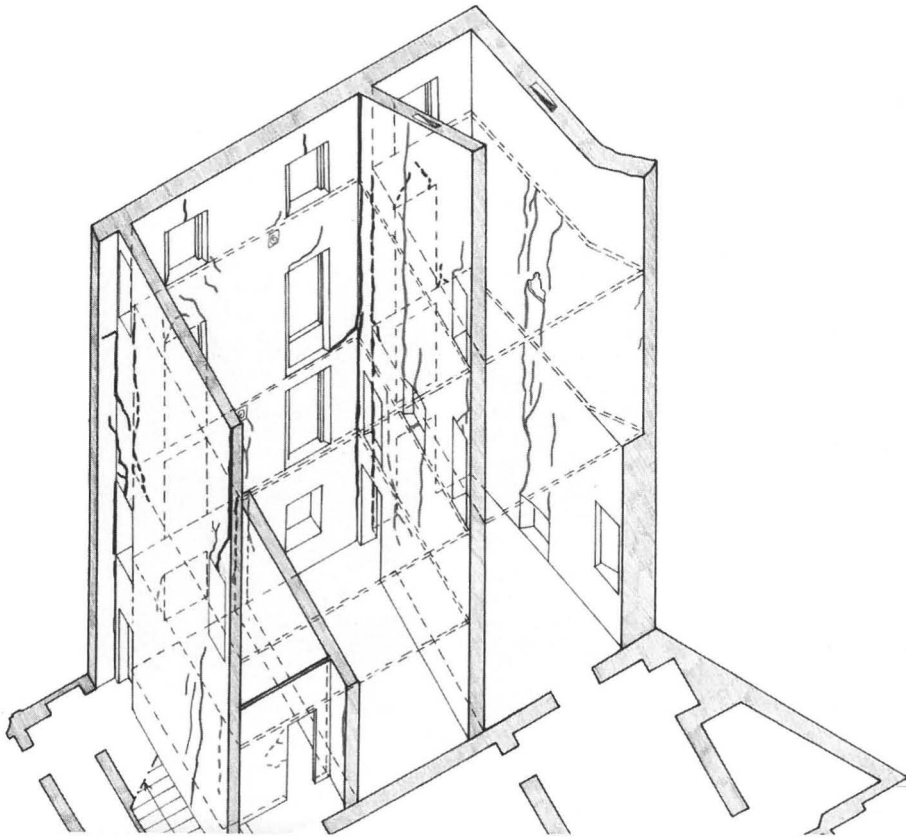


Figure 11. Detail of axonometric projection of the crack pattern with the crack running vertically the whole height between a transversal wall and the longitudinal North façade.

Openings and chimney wells are “weak points” as far as structural stability is concerned: extensive crack damage is easily detectable particularly where openings and chimneys are not coeval. Near the lintels are to be found “arched fissures” which occur when arches or lintels above the openings become weaker because of changes in the stress distribution in the wall.

Alterations made in the bearing walls, such as those mentioned above, have jeopardized the structural stability along the years. In the northeastern part of the building some large cracks have been spotted at the junction between North front wall and bracing walls, signalling a possible cinematic mechanism in the North wall. The most critical area is on the first floor where the wooden ceiling previously connecting the bearing masonry members is almost totally missing in one large room. Its collapse followed years of water leakage through the roof, caused by lack of maintenance and consequent material decay.

The cracks at the junction between transversal and longitudinal walls indicate the lack or loss of masonry “toothings”, which may produced a cinematic

mechanism. This construction defect is related to the multiple construction phases, as well as to the many doors, located in the orthogonal walls but too close to the north front wall (some of these doors were later walled up although with too thin masonry). In the third development phase, along with the walling up of some of these older doors, demolitions have taken place to open new doors in the same bracing walls, but this time too close to the longitudinal wall. These operations have further weakened the masonry.

Close examination of the crack patterns on the outer and inner faces of the north front revealed that a cinematic mechanism has taken place, limited to the portion to the east of the main entrance (Fig. 9).

A number of factors seem to have concurred to this situation, starting from the presence of the “void” created by the entrance-hall and the porch, continuing with the lack of connection between the walls built in second phase and the tower-house; as well as the new large windows added in the third phase; finally the thrust added by the orthogonal walls of the new structure built in third phase onto the northern walls.

The generated cracks run diagonally on the façade, along lines which, observed together, seem to draw an arch. This “arched” pattern clearly indicates a vertical translation in this portion of the façade (Mastrodicasa 2002).

To these cinematic mechanisms is to be added the outward rotation of that same wall, which can be attributed mainly to the above mentioned collapsing of the ceiling between the first floor and the garret – and consequent loss of a constraint – and further to the thrust of the rafters of the new roofing built in 1982. This thrust is unevenly distributed by the new concrete ring beam, which is not completely closed and, moreover, increases the load on the wall (Fig. 13). Therefore, this portion of the façade can be described as a “slender” wall, loaded on its extreme points, and outwards-bulging. To this wall remain two bonds: the corner wall to the East and the foundations which anchor it to the ground (Mastrodicasa 2002).

The following remarks regard the state of the foundations of the building and its urban and environmental context. The Palazzo Cittadini-Stampa was built very close to the meeting point between Naviglio Grande and Naviglio di Bereguardo. From these main water channels several ditches run southwards irrigating the land around the palazzo (mainly rice fields and water-meadows). To the East of the palazzo – right beyond the so-called “Osteria”, an ancient inn – there used to be an irrigation source (fontanile), which is still registered in the 1904 map of the Cesato Catasto (former register of the land property). Therefore, the “water” factor might have influenced the structural conditions of the Palazzo Cittadini-Stampa. Rising and sinking of the Naviglio’s water level, as well as twice-a-year draining in order to clean the river-bed may actually have varied the soil water content and therefore altered the state of the foundations.

4 A WORK IN PROGRESS

The detailed study and analysis of the Palazzo Cittadini-Stampa enables to draw few additional remarks on its present state of decay, although these do not mean to be conclusive and will require further in-depth research and monitoring.

The above description of the crack pattern present in the building has in fact been drawn without the help of an instrumental monitoring, prolong enough in time to detect possible cinematic mechanisms still active. It is suggested that further check and monitoring of damages be started as soon as possible, not because the present conditions of the Palazzo put at risk its structural stability but because data collection of this kind need to last over a year in order for the data to be significant. All data gathered until now can

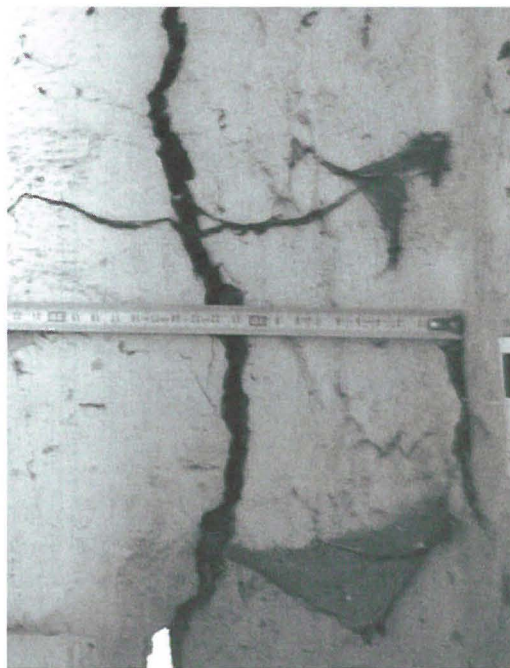


Figure 12. A detail of the crack of Figure 11.

nonetheless be of practical help in order to set up a plan for instrumental monitoring.

Therefore it is recommended to set up a monitoring systems over a significant period of time (18 months) in order to ascertain any changes in the crack patterns detected, as well as possible active cinematic mechanisms – translations, rotations, collapses – concerning structural macro-elements such as walls, openings, roofing, foundations etc. It would also be advisable to check the stress distribution and strength of the walls, for instance through diagnostic tests with flat-jacks both single and double (Binda 1979).

Only after the completion of a thorough diagnostic survey it will be possible to draw a suitable and well-focused consolidation project, which will presumably involve:

- closure of the reinforced concrete ring beam (Fig. 13),
- installation of metal ties both to contain the thrust of the roof and, at the ceilings, the walls’ relative movements,
- consolidation and partial substitution of the wooden ceilings to improve their bearing capacity,
- verify the existence of a basement with the possible aid of geo-radar technique or focused digging, in order to assess the actual depth of the foundations.

Further in-depth stratigraphic analysis will be possible on the basis of the outcome provided by historical



Figure 13. A detail of the ring concrete beam in the attic.

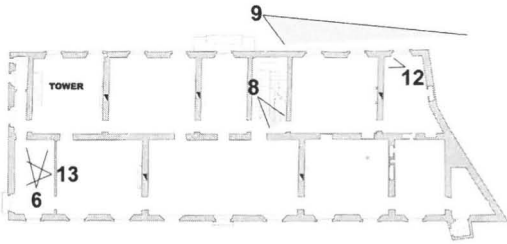


Figure 14. Photographic views location in the building.

and documental research and, if necessary, with the help of limited sample tests on the masonry.

It is here underlined the relevant role of non-destructive investigations in gaining specific as well as global knowledge related to the building and in assessing its environmental conditions. With this aim it is possible to integrate instrumental monitoring with psychometric and thermography tests (Binda 1997).

5 CONCLUSIONS

Thanks to a multidisciplinary analysis approach it has been possible to formulate considerations specific to the material and the structural decay of the building in object, and to highlight causes and effects, synchronicities and diachronicities.

The passing-through cracks, the weak points of the building, the active or possible future cinematic mechanisms, the rotation freedom of a portion of the North front are all parameters which indicate specific vulnerability of this building due largely to its configuration of aggregate of not-coeval structures.

The formulated observations have allowed to put forward some hypotheses related to the causes of the present structural decay. Although further deep analysis and monitoring will be needed, the collected information are already a valuable input to the intervention and strengthening project, contributing to direct and quantify it.

The analyses carried out and those still necessary to correctly define the building preservation project may well be specific and specialized studies, but with the ultimate purpose of punctually preserving the historical material which the building still houses. Therefore these will have to be coordinated and compared according to the multi-disciplinary approach which is necessarily involved in this kind of intervention.

The resulting analysis and interpretation outcome will provide clear guidelines for a careful and respectful re-use and strengthening intervention project.

NOTES

1. The post-grad course FSE n. 86947 (dir. S. Bortolotto) included the following units: Archeological, architectural and urban restoration: theory, history and practice; Historical and documental research methods; Direct and indirect sources for archaeological research on elevations; charting and plotting; diagnostics; multimedia techniques; business planning and legislation. Post-graduate students and researchers attended the on-site workshop: G. Capitanucci, C. Colla, M. Iezzi, C. Liverta, C. Miedico D. Mirandola, M.V. Piva, A. Sponchioni, M.P. Taliento; graduating students: C. Cipollini, M. Pozzi.
2. Diagnostic analysis included: thermography, moisture tests, microclimate charting, inspection of the wooden structures.
3. A CD-Rom was produced at the conclusion of the on-site workshop: "Il Palazzo Cittadini Stampa a Castelletto di Abbiategrosso" ed. by S. Bortolotto with M. Dell'Orto and R. Mastropirro.
4. Topographic survey with total laser station has also served to verify a series of the building's structural behaviour (out-of-plane, misalignments, spalling walls).
5. Special thanks to Professor Luigia Binda for her kind help and useful suggestions.

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