TRACES OF HISTORY IN THE SEMI-ABANDONED VILLAGES HIT BY AN EARTHQUAKE: ELEMENTS FOR A CONSCIOUS RESTORATION

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Aerial view of Casentino (L'Aquila province, Italy) (source: Carocci et al. 2010).

The article focuses mainly on villages that are abandoned or semi-abandoned as a result of an earthquake. The problem of abandoning some Italian villages, located in inland areas and therefore less attractive for tourism, is evident and has been under study for some time. However, the historic villages in seismic areas are among the most fragile elements of this system. Often, in fact, the earthquake accelerates and emphasizes a process already underway for some time: the progressive abandonment. The issue of the abandonment of ancient villages, in this context, is strictly connected to the possibility or not of guaranteeing their safe use; only by achieving this last goal is it possible to preserve them. Securing the structures of the village is therefore an indispensable prerequisite for use; the use, on the other hand, is a condition for the material conservation of the village itself. This last step, however, is not obvious; in order to achieve good material conservation, detailed knowledge and some caution is required. There are in fact specificities and peculiarities that need to be taken into account in the analysis of these villages. What elements are also important for an effective static analysis of masonry and what changes if they are individual parts of autonomous building units or if they are parts of structures linked to each other? What elements are useful for a good understanding of the collapse mechanisms of masonry? And what elements of good historical practices are to be taken into consideration for a real conservation of the material consistency of these villages? Is it possible to combine static safety, good use and fruition with the conservation of the villages themselves? These are some of the questions that we tried to answer with a first research started following the earthquake of 6 April 2009 in L'Aquila carried out by the research units of the Faculty of Architecture of Syracuse, the University of Genoa and the CNR-ITC and continued in subsequent years. A multidisciplinary analysis was then carried out on the individual building and the village with the aim of reaching an overall interpretation of the various aspects that contribute to the stability of masonry built with traditional historical techniques.

Keywords: Conservation, traces, history, restoration, architectural archeology, earthquake

Traces of history and elements for a conscious restoration:

The terms "traces of history " and "conscious restoration" are two closely related elements. This article will show how a conscious restoration can be achieved through the reading of its historical traces. We believe his assumption is true both for a historic building and a multi-layered architectural complex, but it is even more appropriate while dealing with an entire historic village or even a whole seismic area. In particular, in this article we want to deepen the role that the high archaeological analysis had (horizontal and vertical stratigraphic analysis

Figs. 2a - 2b
Left: Thematic map relating to the presence of anti-seismic devices. Right: Thematic map relating to the study of the different evolutionary phases of the aggregates (source: Carocci et al. 2010) Amatrice (RI). (Veronese, 2019).

of individual buildings, analysis of masonry techniques, mineralogical petrographic analysis of mortars) applied to the walls of the various units of a village. This analysis proved to be extremely useful as it highlighted the different phases of construction, abandonment and partial reconstructions which also occurred at different times and as a result of different seismic events that occurred over the centuries in these areas. This was useful not only for a good understanding of historical events but also for the structural analysis of the walls themselves, highlighting the criticalities and weaknesses of the structures and thus allowing a more conscious drafting of the guidelines laid down for their material conservation. So, we can say: traces of history to recover in order not to lose the historical memory of the village, its material and immaterial heritage; historical traces to better understand the statics of buildings and therefore to design conscious restorations even from the structural points of view (Boato, Pittaluga 2000).

Casentino example:

Repair interventions, seismic improvement and reconstruction - necessary for the recovery of functionality and safety and at the same time for the conservation of the residential buildings of centers affected by a seismic event - cannot be separated from a phase of preliminary and careful study of the building typological aspects, its construction schema and the way it got damaged. This concept was applied to the study of the town of Casentino, an historic center hit by the L'Aquila earthquake of 6 April 2009 (Fig. 1). On that occasion, a "Code of Practice" was prepared that could guide the recovery interventions on the entire village. This Code of Practice, on the one hand, kept in mind the characteristics of the local Casentino building and, on the other hand, complied with the new Technical Standards for Construction. Therefore, systematic data collections and analyzes were carried out, which form the basis for the interpretation of the state of damage present and for the consequent setting of the intervention criteria. In particular, the methodology used envisaged an articulation in three sequential phases: the cognitive phase, the interpretative one and finally that of defining the intervention criteria. Focusing in particular on the cognitive phase, the article describes the methodology adopted and the tools designed to carry out the systematic collection of data on the behavior of buildings in aggregate. In this severe situation, issues relating to conservation, safety and functional recovery were the key ones. The starting point for the formulation of any tool, aimed at defining the most appropriate criteria for the repair, seismic improvement and reconstruction interventions to be adopted, can only consist in a preliminary and careful study phase. It is this phase that in fact guarantees the indispensable and appropriate contextualization of more general knowledge on the seismic response of historical buildings acquired, for example, from the analysis of previous events. As regards the field analysis, it was structured as follows: 1) systematic collection of data on the behavior of buildings in aggregate and 2) correlations that can be established between the observed damage, the state of conservation, the local construction technique and the historical-evolutionary phases of the building fabrics (Fig.1)

“Knowledge” phase:

This phase can be divided into two distinct parts: 1) survey of building units and blocks 2) analysis of the local construction technique. The first involves the survey of the typological aspects, of the constructive characteristics and of the damage to the scale of the single block (and more specifically, for each block, to the scale of the single building unit); the second, after the systematic examination of the collected data, is followed by specific in-depth studies for the elaboration of recurring examples of the individual construction elements and assemblies that characterize the local construction of the vertical and horizontal load-bearing structures, of the recurrent interventions carried out and of the anti-seismic devices installed).

Survey of building units and blocks.

The preliminary organization of the field surveys was carried out on the basis of the basic cartographic documentation available, in particular the regional technical map (CTR, scale 1: 5000), integrated with some information acquired from available aerial shots. After the survey of the blocks, the “map of the Building Units (B.U.)” was drawn up (Figs 2 a, 2b).

The survey of each block was carried out in the manner described below, using a two-step, progressive in-depth approach. In a first step, a survey was carried out exclusively from the outside, through the creation of campaign sketches, annotations and acquisition of photographic documentation, proceeding with the following purposes and activities:

1. schematic survey of all the street fronts of the block with evidence of injuries, collapses, chains and other anti-seismic devices: this operation is aimed at providing an accurate picture of the post-earthquake state of affairs;
2. survey of the apparent number of floors on each street front: this operation is aimed at the reconstruction of the consistency in elevation of the block;
3. identification of the positions of the walls orthogonal to the front: this operation is aimed at reconstructing the planimetric configuration of the block, identifying the individual wall cells;
4. notes on the phases of evolution and transformation of the building body through the highlighting of juxtapositions and / or clamping between the walls;
5. notes on historical anti-seismic devices where any, construction peculiarities or evident traces of recent structural interventions;
6. realization of a systematic photographic documentation of the post-earthquake state
   The set of such information collected in the field and the planimetric and volumetric reconstruction of the block support the identification of all the B.U. that make up the block. In fact, based on the information in the regional technical map and orthophotos, it is only possible to carry out a preliminary identification of the B.U., which sometimes doesn't' correspond to the housing units or the cadastral subdivision, which must then be verified in the field, for example on the basis of the traces found of the subsequent transformations undergone by the aggregate. The B.U. identification obtained in this phase of external analysis could be subject to further revisions resulting from subsequent levels of study as internal surveys, detailed historical studies of the evolutionary phases of the village, etc. The identification of the B.U. represents a fundamental step not only to allow a systematic acquisition of data but also for a consistent interpretation of the damage. For each B.U. a special "survey form" has been prepared for the systematic collection of construction characteristics information (vulnerability and protective elements) and on the damage suffered; this form includes graphic sketches, notes, photographic documentation. This form is not a consolidation of buildings recognition, it is also the vehicle for a reasoned and structured synthesis of the this technological, constructive and damage survey. In this sense, it represents a

preparatory tool for the subsequent interpretative phase. The form has three main sections:

1. general B.U. information: position in the topographical context and in the aggregate in which it belongs to, general maintenance status, total number of floors
2. constructive survey of the B.U. It includes a part dedicated to the general transformations undergone by the B.U. (presence of leaning volumes, elevations, some dimensional data) and in a part specifically addressed to the acquisition of data relating to horizontal structures and vertical structural elements. All exposed (or partially exposed) perimeter walls are identified, numbered and detected, through the appropriate field in the card, which identify the actual floor plan of the B.U.;
3. detection of the damage and the identification of the activated mechanisms (specifying the location with reference to the individual structural elements identified in the previous section of constructive significance). This section describes the structural elements affected by the damage (walls, floors, vaults, roofs, secondary elements) and the types of damage that occurred (in particular, for example in the case of walls, distinguishing between the activation of "out of plane" (with collapse due to loss of equilibrium) and ruptures due to actions in the plane (where the damage is associated with the breaking of the material that causes the loss of load-bearing capacity of the structural element).

It is important to point out that the fields on the card have been particularized taking into account the specific construction characteristics present in the town of Casentino.

Analysis of the local construction technique:

After the systematic examination of the data collected at the scale of the individual B.U. and of the blocks of the entire historic center, specific insights there are, aimed at the general extrapolation of recurring examples of local construction technique regarding individual construction elements or assemblies. A special attention was paid to the study of the masonry quality, the arrangement of the vertical and horizontal load-bearing structures, the recurrent interventions carried out and the anti-seismic devices installed. Twelve samples of masonry textures were found, considered representative of the different types found in the B.U. Each sample was cataloged, non-destructive tests were performed (sonic tests, sclerometric tests, endoscopies), for mortar and stone materials samples were taken on which further characterization tests were carried on in laboratory. In relation to the disposition of vertical and horizontal load-bearing structures particular attention was paid to those details that play an important role in the overall seismic response of the building: angle-connections, the "masonry hammers", the connections between walls and floors or roofs. The historical and recent anti-seismic devices have been studied, where present: metal and wooden chains, spurs, shoe grills, arches of "sbatacchio". These analyses help to identify some intrinsic weaknesses of the local technique and those measures that instead favored an adequate seismic response.

Interpretative phase:

This phase is carried out starting from the correlations established between the different types of information acquired in the previous cognitive phase. Therefore, a fundamental aid tool for identifying the causes that favored the activation of some recurrent damage mechanisms or modes lies in the comparison between thematic maps designed to summarize, for example, the state of damage and the constructive global maps (configuration of the aggregates, historical evolution-transformation phases) and detail maps (construction technique, presence of anti-seismic devices, recent structural interventions). These interpretations are based on the survey forms. In this case data were entered into a GIS system (Geographic Information System) that allows the rapid creation of thematic maps. A further step of this phase is represented by the correlation between the qualitative data acquired on the masonry quality and its quantitative characterization through the mechanical parameters to be adopted in the design and verification phase. The study activity launched in the historic center of Casentino outlines a methodology for carrying out the cognitive and interpretative phases of the seismic response that could also be applied in other contexts. These phases are preparatory to the definition of intervention criteria that are contextualized to the characteristics of the local building examined from time to time. In the specific case of the historic center of Casentino, the reprocessing of the acquired data will thus provide the useful elements for the drafting of a "Code of Practice" for repairs, seismic improvement and reconstruction - necessary for the recovery of functionality and safety and at the same time to the conservation of the residential building.(Carocci et al. 2010).

Archeology of architecture and understanding of what exists.

What has been done in Casentino is the result of a new approach to existing buildings. With the Seismic Ordinance 3274 of 2003, in fact, there are important innovations in the Italian technical regulations. In particular, compared to previous regulations, there are innovations on 3 different levels: 1) knowledge and surveys, 2) calculation models, 3) intervention techniques. The importance of knowledge is clearly expressed, identifying different levels of knowledge in relation to the type and number of investigations performed. Depending on the level of knowledge reached, the safety coefficients to be used in the tests are modified through a confidence factor (FC). Basically, a sort of reward is introduced for the investigations carried out. This approach does not guarantee, in itself, a real synergy between knowledge and structural analysis, but it represents a first concrete step. A second important aspect is the inclusion of calculation models that are more in line with the real behavior of the construction, unlike the provisions of previous regulations which required buildings to adapt to the models (Boato, Lagomarsino 2011). In this change of course the importance of knowledge of the historical structure is clear. The archaeological analysis of the elevation, with its attention to the different signs present on the walls, allows us to identify the construction and transformation phases of a building, a complex of buildings, a village. The application of this method of analysis in Casentino has made it possible to highlight some fundamental elements for understanding the instability detected and also, in some cases, the good performances shown by the ancient structures. It is necessary to be aware of the basic principles of this method; it is also necessary to adopt some specific precautions when approaching contexts as this one.

What to observe and how to observe: the architectural archaeologist's point of view.

In contexts such as that of Casentino, can we list the "observation areas" and the parts or aspects of the building to which the architectural archaeologist should devote more attention? As a general rule, all the archaeological observations are useful for a better knowledge of the building, the archaeologist must not neglect any data and must describe everything that comes before his eyes with the utmost precision and completeness; however, this post-earthquake situation, with special urgencies, requires to organize the observation on the basis of the problems or questions that must be answered now. In this case, the problem is the structural behavior of existing buildings: observation, therefore, must focus on everything that directly or indirectly influences this behavior.

Architectural archeology investigations, in general, can have different objectives:

- The analysis of a specific construction, whether simple or complex, to understand how it is and how it became such.
- The identification of "construction rules" adopted in different territories and in different historical periods.

In both cases, the next question to try to answer is whether the solutions used in the single construction or in the territory studied are (or are not) characterized by good construction quality and whether they can be considered reliable and durable, both in conditions during normal operation, and in exceptional conditions. Specifically in the study of perched villages, such as Casentino, this way of proceeding is respected but there are also other elements of complexity. In fact, it is necessary to add another element: the aggregate, the group of building units closely connected to each other and which in some cases can even include the entire country. It is necessary to understand how some transformations include several buildings adjacent to each other and how the transformations carried out can have an influence far beyond the single building unit. It is important to understand if there is a certain homogeneity of materials, techniques and if there are (or not) links between different buildings, between different construction elements. In villages subject to repeated seismic events, we found construction elements belonging to very different chronological periods. In some cases it is decades of difference but in others even centuries. In the case of analyzes such as those carried out in Casentino, moreover, we find ourselves in a more complicated situation as, often, the interventions carried out following an earthquake in the past took place in the immediacy of the emergency, also recovering material where possible. In these areas, moreover, seismic events occur several times and therefore, it is not uncommon to have a complex stratification, with several units and with inhomogeneous materials.

What to observe for understanding the statics of the whole complex?

In simple and small constructions, the number and quality of the existing stratigraphic ante-post relations at the level of the structures is likely to be minimal. However, when a large building is built and the construction continues over a long time, suspensions and resumption phases will be inevitable; this situation produces changes in the building practice, e.g. masonry, joints but also differences in the ways of laying and equipment of the parts built in sequence. What needs to be focused on is the nature of the links existing between the different walls, between walls and floors, between walls and vaults, between walls and roof and between different parts of the same structure. It is necessary to study the interfaces, the nature and conformation of their edges and on all those "micro-stratigraphic" discontinuities typical of construction site sequences: expansion joints, waiting edges, deferred insertion of parts, progression per "pontate". These details could be neglected in other situations, but they become crucial in a situation like the one of Casentino, it is important to realize combined stratigraphic observations of the structures. Even the discontinuities of a microstratigraphy can constitute lines of intrinsic and potential weakness. In short, attention must be paid to all those areas which, having even slight solutions of continuity, could prove to be more vulnerable to seismic action. Furthermore, it is also necessary to pay close attention to the quality of the materials included in any repairs: they must neither be of too inferior quality compared to the neighboring parts nor too superior (in this case, in correspondence with a seismic action they could lead to a "hammering" effect on materials nearby.

What, then, are the concrete elements that the archaeological analysis of elevation could bring for the purposes of static and seismic checks?

- A first attention point the evaluation of the masonry quality and the recognition of any traditional anti-seismic techniques. "Even on the occasion of the L'Aquila earthquake, the main cause of the damage was attributed, simplistically, to poor quality walls; It cannot be denied that the problem exists, but it is not even conceivable that an area so tried by earthquakes has developed a "rule of the art" for the construction of the wall faces which is absolutely deficient. Non-destructive (or slightly destructive) diagnostic investigations for the onsite characterization of masonry properties (diagonal compression on panels, flat jacks, sonic investigations, sclerometry, penetrometers) can provide useful information, but are affected by considerable uncertainties, especially in the presence of irregular masonry. It is necessary to use the typical tools of he archeology of architecture : the degree of clamping present in the building faces and between the different faces, the characteristics of the mortar (Boato, Lagomarsino 2011).
- A second theme is that of the use of stratigraphic analysis in the context of structural and seismic checks, or the development of structural analysis models that take into account the evolution of the building over the centuries (Pittaluga 2009, 185-196; Calderini *et al.* 2006; Boato, Lagomarsino 2011). "*In most cases the calculation methods analyze the building in its current state, but it is clear that for a correct evaluation of the stress and deformation states it would be necessary to take into account the construction sequence, as well as the continuity solutions present between masonry built in different stages. This can be considered in a simplified way through partial models by identifying the most likely collapse mechanisms on the basis of the weaknesses recognized by the stratigraphic analysis. There is also the possibility of performing finite element analyzes, in cases where this method can be considered reliable, which consider the temporal evolution of the construction. For example, if a buttress has been added to a building following the rotation of the wall (as a garrison), this will be less stressed than if it had been built at the same time as the construction; similarly, the stress state in the infill masonry of a previous opening will be very modest, while adopting a finite element model that considers a single construction phase, this will be more compressed, with consequent less stress in the original portions of the masonry* "(Boato, Lagomarsino 2011).

Conclusion

In conclusion, there are several good reasons to try to read the historical traces of constructive and / or transformative events present in our historic villages:

1. study the historical traces to understand the reasons for deterioration and static instability
2. study the historical traces to identify possible areas of future weakness
3. study the traces to understand the reasons for good resistances and excellent static performances
4. study the historical traces to understand the history and experience of these villages

   ... but the main reason is only through an accurate knowledge and understanding of these traditional ways of building, it is possible to think of real recoveries of these villages in full respect of their material and immaterial conservation.

Indeed, this approach allows a better knowledge of the historical structures and correctly manages the complexities of the historical villages. These are multi-layered contests, often the transformations and repairs in a building unit also affect the one adjacent to it. This study, continuing studies also launched in other university contexts (Fiorani 2020, Acierno 2020), considers the village as a whole and allows a determination of the risks linked to the danger of the specific territory. Furthermore, it also allows to identify in a specific territory the resources and the precautions implemented in the past. It prevents the lack of knowledge of the historical structures and their possible static reserves today producing damage by imposing invaded and hardly compatible modern consolidations on them. As Tiziano Mannoni said "*we cannot accept that our ignorance of this tradition makes us declare insecure a structure that has worked admirably for many centuries, while we do not yet know if the modern structures will have the same duration, even if we are able to calculate them, considering that very often the current underestimation of building yard practice makes them much less durable than expected*" (Mannoni 1990, p.3).

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