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HISTORICAL TIMBER FRAMED STRUCTURES. AN EXPERIMENTAL SHEET FOR DIAGNOSTICS AND MONITORING

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Abstract

The attention for the historical wooden structures is located in a planning framework with particular relevance about the history of the territory and the conservation. This architectures illustrate how communities and builders were able to provide efficient, cheap and resistant human settlements using local resources and how knowledge and know-how were developed around these "non-engineered" technologies. To understand this framed structures is required to have specific knowledge and skills so that emergency prevention works, such as renovation or restoration, would be conducted in accordance with cultural heritage protection policy and with consideration of technology. The knowledge of the material culture can increase studying and identifying a certain number of buildings samples with innovative and traditional tools. This approach add new and original elements to the studies on the pre-existences and the history of the territory of the valleys: diagnostic analysis and architectural survey allow to set up an appreciable documentation elaborated with the contribution of the population in situ. Innovative is the application of an experimental sheet able to catalogue the macroscopic and microscopic characteristics of each structure. Important problems are related to the study of the ancient wooden structures, especially if we want to achieve the objective of protecting them with the active participation of the citizens, in particular that of legislation of preservation-valorization of historical heritage. In fact, since the diagnostic analysis allows to broaden the knowledge of the historical heritage, the results can be merged into the measures already prepared by the regulatory plan, such as the strengthening the approach to the theme of "preservation-enhancement" of the historical heritage and the nuclei of the individual localities and the deepening of the regulations on the subject.

1 A RENEWED APPROACH TO THE PLAN IN THE EXPERIENCE OF THE VALLEYS IN CANTON OF TICINO

The urban town planning about the analysis of historical structures involves both cataloguing the existing and a cognitive analysis about the landscape and the socio-economic conditions.

Each valid update of regulatory plan must start in a thesaurus composed by an analysis about the agricultural evolution-involution activity, the socio-economic development opportunities and the material culture.

The involvement of the inhabitants, as bearers of the territory culture, is really important. The ancient wooden structures, based on constructive models refined over the centuries, demonstrate how in the past urban planning and architecture looked in the same direction, the common good.

To increase the knowledge of material culture, some significant buildings have been identified on which innovative and traditional analysis tools have been applied. The architectural survey and the diagnostic analysis allow to acquire sufficient data in order to achieve the planning, economic and social goals of the municipalities but also to meet the owners who intend to face a restructuring.

The current Urban Planning Regulations must be updated by extending and renewing the vision on the territorial future by implementing a synergy with the local authorities and with the population, including the peripheral valleys. (C.K.G.)

1.1 Evolution-involution of agricultural activity

Knowing the evolution-involution of agricultural activity is important for a correct territorial reading. The presence or not of this kind of activity, especially in a context such as the one of the valleys, has a decisive influence on the landscape, not only in its natural forms but also in its anthropic tissue. In many territorial compartments the configuration of the territory with its slopes constitutes an obstacle to continue cultivation and unfortunately often also the rural traditional use of the buildings located in it, as the following extract of the Map of the vineyards in sloping areas, Federal Office of Agriculture of Lugano.(Fig.1)

Figure 1: land intended for cultivation (in light blue) in the mountain areas above Lugano.

The construction and dimensional characteristics of stables, barns and farmhouses are also taken into consideration because the knowledge that the needs of farms, as well as the sector-

specific regulations on the subject, have profoundly changed. These issues should not be overlooked precisely because included the agricultural suitability of the land, which is still a positive factor and a value to preserve. For the territorial reading we used historical cartography, but looking back in time makes sense if the aim is to identify a possible territorial future. Extending the use of settlement assets to renewed functions is feasible if it is based on knowledge and appreciation of the hard work that past generations have done. The will of some local authorities to support cultivation, mowing lawns and cleaning the land is only the first step in a process aimed at giving continuity to work in the mountains. (C.K.G.)

1.2 Turism and new opportunities

Some Urban Planning Regulations established a link between the possibilities of intervention on buildings and land and new possible uses and alternative activities to traditional agriculture (Cantonal Decree 8 Nov. 1999) which must necessarily be updated with ad-hoc initiatives, including the territorial culture chain, the agricultural activity chain, and incentives for widespread receptivity (New Regional Policy). The granting of subsidies for lost funds, the recovery of rustic buildings worthy of conservation to be leased, such as tourist accommodation in the peripheral districts with the aim of increasing tourism for the stay, facilitating the maintenance of properties, are part of a project to enhance cultural heritage, of local knowing and artisan products (Rustici Decree lapsed 31 Dec. 2016)

Within the framework of the new Regional Economic Policy and in particular the Program for the implementation of Regional Economic Policy (2016-2019), the Canton of Ticino has intensely questioned the future of particularly disadvantaged mountain regions by developing a specific program to support peripheral regions.

The regional policy interventions aim to think about the formula of the widespread hotel, which pursues environmental sustainability objectives, which can undoubtedly incentivize individuals, young entrepreneurs, agencies and public authorities to move and innovate the tourist offer, also creating new opportunities of work. This type of accommodation helps small towns in the mountain area rich in history and traditions. (C.K.G.)

1.3 Material culture in relation to historical memory

The territory is a manual of the art of building, a teaching for today. Looking to the past to improve the future produces tangible results if we work on material culture: the ancient buildings in the first place, but also the dry walls, water drainage devices, particular sections of the path that draw the ground in a masterly way. Knowing the urban layout gives the opportunity to deepen the knowledge of the heritage and to bring new elements of knowledge of the material culture in its articulation of constructive knowledge, in the belief that it can profitably be made visible to the population and tourists.

The redevelopment of buildings and artefacts, thus becomes "production factor", in the face of concrete and objective obstacles (linked to the characteristics of the territory and the market), also agricultural activity also helps to achieve the full exploitation of the territorial potential in the territories mountains (in terms of land, human capital, historical-cultural and landscape). It is a determining factor to promoting an attractive image for a renewed tourist offer and this also reconnecting to the analyses on the sectors of activity previously expressed.

Here are some notes on the analyses to be performed:

- the architectural survey is an undisputed instrument of knowledge of the buildings [1]; it is not out of place to underline how for many architects, such as Carlo Mollino and Franco Pessina, the traditional construction knowledge, in particular of the Alpine regions, is decisive.
- the diagnostics applied to wooden structures has the purpose of giving certainty and reliability to reactivation or restoration interventions through the objective determination of the state of conservation and structural functionality. The objects are selected on the basis of the indications of the bodies involved, paying attention to the state of conservation, to the opportunities for coordination with the protection instruments already in force (in particular the federal inventory of Swiss settlements to be protected of national importance ISOS) at the level supra-municipal and municipal and the concrete possibilities to carry out the diagnostic investigation in situ.
- the opportunity is given by the existence of projects that aim to know and evaluate the cultural heritage constituted by the framed structures, through diagnostic analysis in different locations in Ticino, where it is possible to find objects of great interest (the list of locations will be screened in the operational phase). STAN, the Ticino Society for Art and Nature, is in the process of being involved, also for the choice of objects to be analysed. (D.P.)

2 SURVEY METHODOLOGIES

The knowledge of the building is fundamental within the project of recovery and restoration and includes many choices that the detector should makes.

Investigation about the materiality of architecture shows contradictory aspects because there is, at the same time, the exercise of measuring, (quantitative research), but also the critical work (qualitative assessment). Both points of view are legitimate, but are conflictual at the same time because they assume radically different methods and operating concepts. [2]

It is possible to know a building through different levels of knowledge that take place through the action of "detecting" [3] that has many different purposes:

- a diagnostic tool: it provides the necessary frame of reference for any other analysis or diagnosis; it is considered an indispensable basis for any project practice and for any in-depth building's analysis
- a conservation tool: every conscious project arises from the knowledge of its object and that if it wants to preserve, together with the matter, the values of which the artefact is bearer, it must above all know how to recognize, inventory and disseminate the data that describe its consistency and current conditions
- an analytical method aimed at the economic evaluation of the project
- a control tool during construction phase
- a kit for every intervention request

The knowledge of the building is therefore very important for a recovery or a conservative intervention. The information needed to obtain geometric and shape data are commonly known, such as the precise size of the object; instead, in the diagnosis survey the process is more uncertain and it includes operator choices.

The knowledge's field is vast and it is necessary to have a clear understanding of the scope of the investigation and which economic and instrumental resources are available.

All the case studies [4,5] have been analysed using two parallel investigations: historical documentation, written oral and photographic type (Fig.2-3) that could help to understand the structure and the modifications made; the second one is dedicated to the analysis of the building through a visual survey on site to quickly understand the components of the structure.

Figure 2-3: Comparison of Granarolo funicular (Genoa, Italy) in 1915 and 2018.

A good cognitive investigation, functional to the identification of all the structural part must contain: the identification of the ligneous components by code or digit, the position of the components in the structure, the size of the individual elements, the type of constraints and possible signs of repair, consolidation, reinforcements and restorations.

For this purpose a specific experimental sheet (see The experimental sheet) has been developed to identify, understand and schedule the components of the structure. Every single case, unique in its kind, has allowed and still allows critical analysis of the sheet. This tool is in continuous development to try to achieve the perfect combination of completeness, synthesis and versatility. (L.S.)

3 THE EXPERIMENTAL SHEET

The Experimental Sheet is a tool to understand the building technique oh the wooden load-bearing structures; aimed to create a practical code for framed structures, in order to systematically classify and store the building procedures. We identified the characterizing elements, a synthesis between theoretical knowledge and relative visual analysis on the field. Another fundamental passage of knowledge is the study of their historical excursus, through a search among archive sources and historical analysis. In this way, it is possible to understand, where visual observation is not sufficient, the changes that the building has undergone over the years.

Each part of the Experimental Sheet is divided into chapters and paragraphs. Each chapter is dedicated to a specific compositional part of the building and also, it is considered any possible variation of the elements. This is the first level of knowledge, starting from its general characteristics (macro-scale) up to the construction details that characterize it (micro-scale).

All the information are divided into tables and the questions are checkboxes. They contain all the various possibilities of choices with a graphic schematization, where was possible. In this way, the scheduler can use it even in uncomfortable situations, such as on building sites or in abandoned buildings. (Fig.4)

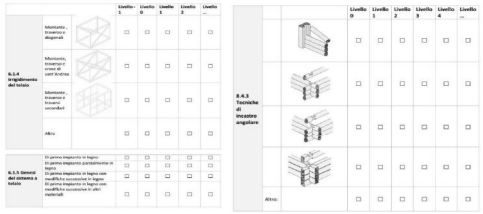

Figure 4: Extracts of the experimental sheet.

The second level of knowledge is given by the application of non-destructive investigations, which allow evaluating the state of conservation of the wooden elements according to the laws. These instrumental investigations aimed to define the state of health of each structural element.

We studied the buildings with frames and continuous elements (blockbau), and we proceed to the analysis and census of these types of constructions present in Liguria and in the Helvetic area. The study of the Helvetic territory has allowed a widening of knowledge that has provided a more complete picture on the construction techniques with a wooden supporting structure. The research in the Helvetic territory was possible thanks to a collaboration between DA&D of the University of Genoa and the CISAPSI (a Switzerland municipalities consortium of Canton Ticino), in order to develop cognitive research about the numerous local wooden constructions. (Fig. 5-6) (C.M.)

Figure 5-6: Selvini's house in Faido (Switzerland) and Church Rectory in Imperia (Italy).

4 DIAGNOSTIC SURVEY

A particular attention was paid to defining methodologies for determining the state of conservation of beam. Instrumental diagnostics has been chosen as the main analytical tool, with specific attention to the relationship between mechanical strength and durability.

In particular, a card has been applied for the Visual Inspection and Classification according to the technical regulations in force both in Italy UNI 11119, UNI 11035_1–2–3 and in Switzerland SIA 251.

The two regulations have several points in common and methodologically are constituted in the same way, however the Helvetic one provides procedures to determine parameters such as humidity and density, giving specific indications about the instruments to use.

For the Classification we proceed to the estimation of humidity (Fig.7) according to the UNI standard with thermo-hygrometer for electrical resistivity and to the identification of the wood species both for macroscopic observation and for laboratory with microscopy analysis on samples taken and prepared in thin section by taking small pieces.

Attention has been given to the connections with the masonry and to the center line of the elements because these areas are object of particular vulnerability and attention to the instrumental investigations that must be preceded by a diagnostic project and relative preliminary inspection that indicates places and times of intervention.

Where it was not possible to Classify the structural wood by visual inspection, we proceeded to increase the knowledge with the diagnostic phase through non-destructive instrumental investigations (N.D..T.) such as:

- the hardness test using Pilodyn test hammer just for limited sections (it must be remembered that the test must involve at least 50% of each wooden dimension investigated)
- the investigation with electronic hammer RESI PD 400 that allowed to determine dendrograms of the various elements investigated. (Fig.8)

The investigation has firstly identified the presence or absence of xylophagous attacks by means of auscultation method with instruments able to distinguish the acoustic signals emitted by insects according to certain frequencies in the wooden elements. (Fig.9)

In particular, for durability a measurement was taken with the removal of sample cores in a position adjacent to the dendrograms of the electronic hammer, taking care not to involve horizontal sections of the wood but only vertical and in points of deformation of the wood and in non-critical points. Subsequently through the millimetre reader with the Tree Core reader the cores are stratigraphically analysed to be able to identify if there were ongoing degradation processes and their position in the sections investigated.



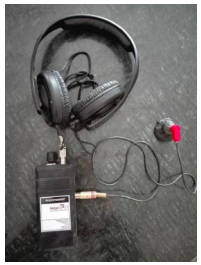

Figure 7-8-9: Non destructive tests: thermo-hygrometer, resistograph and auscultator.

4.1 Developments

Diagnostic developments are being planned for the determination of some characteristic values of the timber. This will be possible through tests on cores taken with Fractometro 2 which will allow to obtain numerical values, therefore quantitative and not qualitative, as most surveys do. This will make it possible to have a better correlation with the characteristic values of the UNI 338/2016 standard to be taken for the calculation verifications. A second deepening will be the determination with LEICA 3DDisto topographic electronic instrumentation that allows to obtain the data, with millimetre precision, about the beam's deformations.

Through the numerical results obtained it will therefore be possible to pass from a not only qualitative but quantitative evaluation of the state of element's conservation and to be able to define their durability. (G. S.)

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ATTITUDE CHANGES IN HISTORIC ROOF STRUCTURE INTERVENTION. CASE STUDIES – GOTHIC TIMBER ROOF STRUCTURES WITH PAINTED ELEMENTS IN ROMANIA

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Keywords: wooden heritage, roof structure, painted coffered ceilings

Abstract

Introduction:
Within the vast wooden heritage of Transylvania, historic roof structures and slabs have a significant role. These values, with the main role of supporting the roofing that protects the building, carry the traces of the time they were created in, the living standards, and the characteristics of the site. The study of these sub-units deserves a multi-disciplinary approach, providing detailed information on the evolution of the building, the type of timber used, however, as load-bearing sub-units they play a role in the transmission of loads through the superstructure.

Developments:
This paper presents different types of interventions performed over time on roof structures and slabs, ceilings and the changes of attitude in timber conservation, highlighting both mechanical and technological aspects belonging to these exceptional timber load-bearing structures. The presence of painted wooden coffered ceilings is a characteristic trait of Transylvanian churches: there are more than 250 such registered churches; coffered ceilings have survived since the 16th century, but they were still made in the 20th century, being one of the main ornaments of the churches. This ceilings are unequivocally load-bearing structural sub-units (slabs), but due to them being painted, they are important artistic components as well! The interventions carried out at the level of roof structures or ceilings range from full replacement, reconstruction or consolidation to preservation. In the case of roof structures these tend towards conservation and consolidation, while in the case of painted ceilings, if possible, from a technological and financial point of view, the coffers are usually carefully dismantled after a preliminary fixing of the layer of paint, followed by material and compositional and/or chromatic reintegration.

Remarks and Conclusion:
Considering this, all types of interventions on roof structures and ceilings should be correlated, even if the interventions on roof structures are not visible, and therefore not always treated as carefully as deserved. Sometimes, a new roof under the original one is built by restorers "saving" the paintings from the ceiling and "distroying" the roof aspect.