Building maintenance: a re-discovered culture

C. Bertolini Cestari
*Dipartimento di progettazione architettonica, Turin Polytechnic, Italy.*

Abstract

There is no doubt that the theme of maintenance, which is rooted far back in time, has recently developed in a complex way to get to the present meaning of “Planned Maintenance”, with all the methods and procedures – sometimes quite sophisticated – that the activities linked to it now require. Nevertheless, much can still be learnt from the treatises and manuals of the past, especially in the vast sector of historical buildings. In the historical technical literature, especially that of the 19th century, it was a common praxis to provide – for materials, building techniques or described works – indications and clarifications on techniques and maintenance instructions, on periodical checks to be carried out, on the most appropriate techniques, on the costs. The present work – which reports the results of a study carried out over many years at the Polytechnic of Turin – analyses maintenance themes and maintenance activity on case studies related to 17th century buildings in the Piedmont area, with references to ancient prescriptions provided by treatises and manuals, with the aim of giving indications immediately useful for the craftsmen of the sector.

1 Introduction

The maintenance culture is very ancient and, until the 19th century, even though it was not clearly expressed, it was related to the very concept of architecture and the concept of its durability. Most of the historical and historical-monumental buildings of our heritage are not typologically characterised – at least as far as the Italian buildings are concerned – by the various materials used as they are always the same: brick, plaster, wood, stone, etc., but rather by the geometrical
variable of the drawing or decorative elements, or by the different space and distribution concepts, (such as space proportioning, room height, planimetric and volumetric layouts, etc.). The building construction required the maximum degree of reliability and curability; the best quality and performance level was the answer to both the functional requirements and the aesthetical characterisation of social prestige.

In the ancient mentality, the operation consisting in building "durable" architectural works required more time than in more recent times, therefore the building was considered as a non finished system, because the task of completing it was inevitably inherited by others than the original designer. Thus the building remained a system that could be adapted and transformed over the years and, with the application of appropriate "workmanship", an optimal quality level was achieved, along with the reliability and maintainability of the product that was being defined and built.

Since ancient times - a heritage of material culture - the rules applied to keep buildings in good conditions have found forms of written codification and transmission, like in Vitruvio's works [1], in the Renaissance treatise writers [2] and in some contributions of the 19th century manuals [3]. All these contributions are aimed at coding the rules of the Art of proper building, as well as the rules to be followed in the choice and correct use of the materials to guarantee durable buildings. By the middle of the 19th century, Quatremere De Quincy [4] defined maintenance as the "care, continuous observation and small repairs that all buildings need" while, in the same period, John Ruskin [5] accused his contemporaries of neglecting the most elementary maintenance rules, declaring that "The principle of modern times ... is to neglect the buildings first and to restore them later ... look after an ancient building with the utmost care, protect it as well as you can and at all costs, from any danger of decay ... and do it ... continuously, and many generations will come and go under its shadow".

In more recent times, the systematic lack of maintenance programming on a building and urban scale, as well as the gradual passing of traditional craftsmanship, have been crucial issues that should be pondered over. The hopes fed by the introduction and use of new building materials have led to the underestimation of the maintenance aspect for the more recent buildings. Only a few decades ago, buildings in reinforced concrete were believed to be very long lasting and capable of supporting the ravages of time as well as aggressive environmental conditions with no need for constant maintenance. Furthermore, today's buildings, paradoxically even more than yesterday's, do not seem to be designed or built to be maintained or modified. For lack of clear and shared performance regulations, the greater technological complexity reduces their reliability and lead to a highly problematic maintenance control [6].

This work – which reports the results of a research programme carried out over many years at the Politecnico of Turin – intends to stress how the consolidated tradition of building maintenance, carefully respected in the past centuries, has found in industrialisation a source of renewed methods and procedures on the one hand, and a breaking point with the designing and technical tradition of "proper building" on the other hand, a tradition that is consolidated and
experimented in the operations aimed at keeping buildings in good conditions. The current complexity of the building sector generates problems that can certainly not be solved with the sole technical tradition. However, it is useful to review – for a building system such as roofing – the specific aspects that can be traced back to the still relevant historical treatises and manuals.

2 An early example of maintenance culture: the “global service” for the Valentino Castle

The concept of periodical maintenance (that is now better known as "programmed maintenance") was already present in the Art of Building between the 17th and 18th century: the maintenance of buildings – both in "learned" architecture and "spontaneous" architecture – used to be a traditional trade for many families specialised in given sectors, and the maintenance techniques developed and improved over the years with practice and experience were handed down from generation to generation. Official documents dating from the middle of the 17th century refer to the maintenance tradition of "learned" architecture, as evidence that a "constant" service of maintenance assistance provided by experts was already appearing in the 18th century besides the building heritage project.

The maintenance service designed as a programme initiative is particularly interesting as it was based on the characteristics of the building and its propensity to decay, i.e. the periodicity of the maintenance interventions was carefully planned right from the designing stage (through the drafting of precise specifications and contracts), as it occurred for the roofing of the Valentino castle in Turin (Fig. 1). In the second half of the 19th century, a constant maintenance service was developed for this building and was entrusted to a specific family of carpenters. In this respect, it should be reminded that, between the 17th and 18th century, ordinary maintenance in all ducal buildings in Piedmont, as detailed in the corporate "Tenders", was guaranteed "from the foundation to the roof" even in the restoration of deteriorated parts, according to items that were specified in the contract with the workers: "wooden" works, or iron works, flooring, plaster, marble, stucco, and stones; wells and eaves; roofs and roofing systems [7].

In particular in 1633 for the ‘Valentino’, the task entrusted by the Duke to the "Savoy carpenter Pierre Rolla and his sons ....to maintain the roofs ...in the buildings in any place of the Piedmont States, providing them with materials and supplies", with the allowance of a yearly salary in addition to the right to reside permanently in a room at the Valentino castle and at the Rivoli Castle, and the assignment of a place to store the instruments needed for their work [8]. The complex bureaucratic system that directly controlled the project and maintenance of the ducal buildings - an authentic expression of the management imposed by the House of Savoy's Absolutism - started declining with the beginning of the French and Napoleonic domination in Piedmont, which involved the abolition of the principle of concurrence between the Crown Endowment and the Sovereign Heritage. In later years, with the Restoration (1814) and the return of the Savoy,
a clear institutional distinction was introduced between the "Crown Properties (or State properties) entrusted to the Ministry of Finance and the "Properties of the private heritage of her Majesty" directly depending on an "Art Office" of the Royal House.

Figure 1: Roof of the towers of the Valentino Castle in Turin (XVIIth), overall view

3 Maintenance interventions on wooden buildings: suggestions of the historical treatises and manuals

Dealing with the survey of the past interventions on wooden structures, with reference to treatise and manual sources, implies an effort to reconstruct a type of experience that we are no longer accustomed to: starting from the arrangement of the wooden elements that make it up, the design of buildings is defined with criteria that take into account the possibility of performing interventions – postponed in time – aimed at improving the structural behaviour and preservation condition of the material [9].

Among the traditional building systems and the materials mainly used in the past (wood, stone, brick) wood actually provides an exemplary opportunity to approach the maintenance and planning of interventions that have characterised the design of structures: from those predominantly used in historical building, such as floors and king-post trusses, to the less common structures such as trusses and centring.
This type of maintenance, focused on the whole organisation of the site, is aimed at preserving the complex entirety and continuous transmission of the ancient building techniques with a programme that can also foresee, according to a criteria "foreign" to the prevailing culture of contemporary restoration, the sacrifice of single damaged frames, replaced with sound wooden elements, quite similar to those being replaced.

The concept of replaceability is clearly expressed by one of the most interesting 19th century treatise writers Emý, a peculiar figure trained at the Ecole Royale des Ponts-et-Chaussées [10], who suggests that, in case of "... deterioration of any piece of a building, it should be replaced as quickly as possible. ..." (Fig. 2).

In ancient wooden buildings, the system of periodic replacement and reuse of wooden elements from other buildings, is often confirmed by accurate analyses carried out on frames to determine their dating: for example, when a dendrochronological survey shows the presence of parts older that the building period, which can often be determined through a simple visual examination when the joints appearing on the various frames are inconsistent with the structure they belong to, such as isolated mortises, traces of wooden pegs and dentition. Moreover, the recurring numbering noticeable on the elements making up the structure enables to put forward hypotheses on the assembly operations, or to distinguish the original parts of elements from those which do not bear any mark and were therefore replaced at a later date.

Within the organisation of the traditional carpentry site, the replacement operation was programmed right from the design of the wooden structure, in order to intervene easily to replace a badly damaged element without disassembling the whole structure. To emphasise the importance of easy replacement in the site economy, it is useful to quote Emý, when he declares:
"...In connection with this, I wish to point out that a very extended carpentry work will be perfect and its construction cost will be well invested if, besides the conditions imposed by the purpose it must fulfil, it provides for the easy replacement of any of its piece, should they show damages such as to jeopardise the solidity of the building and the preservation of the other wooden structures..." [11].

The implementation of this programme was mainly achieved through the appropriate layout of the joints, and one of the aspects that many treatise writers tend to emphasise is precisely the possibility to guarantee the movements in the various directions of the wooden elements converging in the joint. The wide case record of joints presented in the treatises was aimed at defining project criteria that would allow an easy periodical adjustment or replacement due to deterioration, with a simple temporary propping of the structure.

An example that significantly illustrates this replaceability concept is the "open" layout of the joints in some of the elements making up the trusses of the Valentino Castle towers covering. Particular reference is made to the wooden dovetail joints between the struts and the beams elements: the joints were made by means of wooden pegs in more resistant and more durable material than the frames, that could however be removed for replacing the element from the part in which the joint was made. In the whole range of junctions and joints found in the large 17th century trusses of the Castle tower, many of the joints are "closed" with tenon and mortise joints (e.g. between prop and tie beam, between wall beam and tie-beam); on the other hand, the dovetail "open" joints actually refer to the elements laid parallel to the pitch direction, which are clearly more prone to decay than the other parts [12] (Fig. 3).

![Figure 3: Roof of the Valentino Castle, survey: transversal section, longitudinal section](image-url)

A second aspect referable to the maintenance intervention systems concerns the attention given to the prevention of wooden material damage, as a consequence of attacks by biological micro-organisms, i.e. mushrooms and insects, caused by a high moisture rate favouring their development. In this connection, Chevalley, in his 1924 work "Elementi di tecnica dell'architettura", summarising his professional experience as a designer and his teaching experience at the Royal
Politecnico and the University of Turin, suggests that: “...For guaranteeing durability when laying the roof wooden structure, it is advised never to close the masonry (in particular the tie beam and strut heads and the wall beams) to avoid running the risk of quick putrefaction ... of the bracing as can be seen, for example in the recent constructions of the University Buildings of Turin at the Valentino. " (Fig. 4 a,b) And also ". As it is sometimes impossible to avoid walling up, all useful measures to avoid such inconveniences should be previously adopted; ... First of all, it should be checked that the timber is of suitable quality, sound and properly dried; the parts that should be walled up can then be repaired by spreading appropriate substances (paint, tar, etc). Direct contact with the fresh masonry work can be avoided by interposing lead sheets or small boards between the masonry and the beams, after the suitable preparation of the substructure with a stone slab, and placing dry bricks in contact with the timber, instead of mortar masonry. ...[13]. With these suggestions, Chevalley refers to two categories of interventions used for protecting the beam heads from decay: the first one implies the surface treatment of the head, while the second recommends building technologies to isolate the wooden part from the masonry part.

The weakness of the beam heads and wooden tie bars against the attacks caused by moisture is well described by Emy, who shows here again his punctual knowledge in this matter, which probably originates from his long experience on building sites. In this context, he proposes some preventive systems known in those days. One of these systems consists in interposing between the beam head and the bearing masonry, a stone bracket spaced away from the wooden element by means of a wedge in order to let the air circulate, or in placing a lead or copper plate to prevent direct contact between the wood and the bracket. The French author claims that another very interesting method was used in the Castle of Roche d'Ordres, near Bayonne. Emy reports that, during the demolition of the Castle “... the ends of the oak master beams driven in the walls were found to be perfectly preserved, although these beams had been laid there over 600 years before. The whole part of the beams driven in the walls was wrapped in cork, which isolated them from the masonry. ...”. It appears that the same system was also found in the Bayonne church where "... the fir master beams were found to be worm-eaten and putrefied, except for the parts driven in the wall, which were also ... wrapped up in cork... [14].

The continuity outlined in this proposition or in other suggestions that were handed down from a treatise writer to another, leads to some questions on the relation between technical culture and building praxis, i.e. on how much of these punctual techniques are the reflection of a real building tradition and how much is simply transferred from one treatise to another with no operating knowledge of the "art of architecture".

Another interesting solution proposed by the treatises, and frequently found in older wooden structures, is the positioning of wooden brackets driven in the masonry work under the beam and tie beam heads; this operation has a dual purpose, i.e.: a maintenance purpose, aimed at placing an easily replaceable element in direct contact with the bearing masonry in order to preserve the heads
from decay, and a structural reinforcement purpose, involving the reduction of

the deflection clear span.

Figure 4a: Detail of an "open" joint at half wood

Figure 4b: Details of "open" and "closed" joints

4 Conclusions

In the light of the above, it was deemed preferable to review the various stages that marked the preparation or project aimed at the maintainability of a system. Maintenance (related to the reliability concept) as a designing characteristic, taking into account that the building systems adopted in the maintenance framework should be basically considered as part of the problematic area of biophysics, where the environment is an unbalancing variable/instable factor. But also maintenance as a real operation that is not merely theoretical, calculated, processed, taking in account that the national building system has a prominent handicraft character and chiefly consists in small businesses with workers trained on the site, who need clear and simple guidelines that can be expressed in interventions, as they were handed down by ancient workmanship traditions.

The short notes of this report contain the review of some descriptions extracted from the works of treatise writers and intend to supply a line of research for interventions on wooden structures in general, and on roofs in particular, to maintain and restore their static efficiency.

The purpose of the work is therefore a methodological proposal where the central role is played by the knowledge of the treatise sources and the constructions.

The maintenance theme dealt with in the historical treatises— that are too often underestimated and neglected nowadays,— is related to the inspection and accessibility requirements, i.e. the possibility to gain access to the sub-system in order to check the aging or wear level, the possibility of dislocating and
disassembling a damaged element, the possibility of clearly understanding all the elements making up the component and the mutual interdependence of their parts, in order to achieve a punctual and targeted replacement of the only damaged components making up the system.

Acknowledgements

This contribution is part of the specific research theme "Diagnosis and evaluation of the bearing capacity of wooden structural elements at work. For the optimisation of structural verifications in constructions belonging to historical buildings" for which Carla Bertolini Cestari is the scientific responsible, in the framework of the under-project 2, theme 2.3 "Diagnosis of the preservation state and intervention methodologies – Real properties", of the special project "Cultural heritage, Science and innovative technologies of the knowledge, preservation and use of the cultural assets " promoted by the CNR from 2001 since nowadays, also the EU Culture 2000 Project "Wooden Handwork/Wooden Carpentry: European Restoration Sites", and the Project "Venice Arsenal (Old Arsenal)" MURST 40%, 2000/02.

References

[1] Vitruvio's work, De Architectura Libri Decem, set in the Augustan times, is the only treatise on ancient architecture. It describes the regulations and praxis of the art of building throughout the Roman world. In particular, Book II contains the most frequent references to the designing rules that could guarantee the buildings durability as well as the rules relating to the behaviour over the years of the materials used in the buildings. Rediscovered in 1414, Vitruvio became a model for the whole the Renaissance treatise work.

[2] For example A. Averlino a.k.a. the Filerete in the Trattato di Architettura (1461-64); Francesco Di Giorgio Martini in his Trattati di architettura e arte militare (1485). And in the 16th century, Sebastiano Serlio in I sette libri dell'architettura (1537-75); Andrea Palladio in I quattro libri dell'architettura (1570).

[3] For example Rondelet with the Trattato teorico e pratico dell'arte del fabbricare, Paris 1802-17, Choisy in his Storia dell'architettura (1899), or again Violet Le Duc in Entretiens sur l'architecture, 1863-72.


[7] For a more detailed survey of the historical events of the Valentino Castle, refer to Roggero C., Un'architettura di lunga durata in "Materiali per il

[8] The "French style" slated roof of the Valentino was exceptional with respect to the Piedmont building tradition, as in the 19th century (before the final transfer of the building to the State Property Office, 1850) a room of the castle was occupied by two carpenters: G. Battista and Gerolamo Dejeronis, the only ones who still knew how to replace the roof stone slabs and were prepared to go over the roof pitch slope, entrusted with the maintenance over the years, by Roggero C., Un’architettura di lunga durata, op. cit.

[9] For a collection of information and a bibliographical list of the treatises dealing with wooden structures, refer to the second volume of Cravero, S.; Analisi del comportamento statico di antiche strutture lignee in vista del loro recupero funzionale: i sistemi di unione e connessione nella trattatistica e alla luce dei nuovi metodi di calcolo; Graduation thesis discussed at the Faculty of Architecture of the Politecnico of Turin, 1994 (rell. Bertolini, C., Roccati R.).

[10] Emy, who lived in the French Empire and post-Napoleonic times, is the author of a work, probably unequalled for its exhaustiveness and competence, in connection with the geographical area concerned, that became a reference point for many subsequent works. Cfr.: Emy, A. R.; Trattato dell’Arte del Carpentiere; 1a trad. it.; Venice, Antonelli editore, 1856; (original ed.: Traité de l’art de la charpenterie; 1a ed.; 1837-1841); v. I, p. 92.


