PROCEEDINGS

5th International Congress
on
"Science and Technology for the Safeguard of Cultural Heritage in the Mediterranean Basin"

VOL. III

DIAGNOSTICS AND RESTORATION (2nd Part)

(Reprint)

Istanbul, Turkey

22 – 25 November 2011

THE CHESTNUT TIMBER STRUCTURE OF THE ROOF IN SANTA MARIA NUOVA (VITERBO, ITALY): ON-SITE INSPECTION, DATING, ASSESSMENT AND RESTORATION CRITERIA.

Romagnoli Manuela[1], Togni Marco[2], Cavalli Alberto[2], Spina Stefano[1], Capoccioni Valentina[1]

[1]Department of sciences and technologies of Agriculture, Forestry, Nature and Energy (DAFNE) – University of Tuscia, Viterbo; [2]Department of Agricultural and Forest Economics, Engineering, Sciences and Technologies (DEISTAF) – University of Florence

ABSTRACT

The Church of Santa Maria Nuova in Viterbo, is very dear to the people of the town. The first church building dates back to 1080, however the historical information on the roof dates back to the XV century. The church consists of a nave and two aisles. The roof of the nave is formed by 9 traditional timber trusses (king post trusses) made up of chestnut wood (*Castanea sativa* Mill.). The timber beams are square edged, or wane edged. The roof is particularly interesting because it is one of the few painted roof on chestnut wood. The decoration is on elements which have a structural function like purlins and joists so as on small planks and the frame which encloses the fired clay tiles. The whole roof structures was under restoration.The work consists in a wide study to define the correct approach for achieving the assessment of the full timber structure: from the structural components (painted or not) to the non structural painted planks. The different analysis have been carried out in order to assess the residual timber strength and the actual load bearing cross section, to evaluate the possible restoration/strengthening systems and to date wood. Dendrochronological analysis and diagnosis of ancient timber members, according to Italian standards,, respectively UNI 11141 and UNI 11119 were applied.

THE CHURCH

The Church of Santa Maria Nuova in Viterbo, is very dear to the people of the town, also because is one of the very few building survived the 1944 bombing, and that keeps the roof intact.

The first church building dates back to 1080, however the historical information on the roof dates back to the XV century; the church contains a very important Lombard cloister and a pulpit where San Tommaso d'Aquino preached. Inside the church it was stored up the very famous triptych of Santissimo Salvatore (XIII cen.). The church consists of a central nave, ~6.3 m span, and two aisles; totally it is 13 m span. The roof of the nave is formed by 9 traditional timber trusses (king post trusses) made up of chestnut wood (*Castanea sativa* Mill.) while the main loading structure of the aisles is made by rafters, with a slope of ~25°.

WORK SIGNALS ON STRUCTURAL ELEMENTS.

The size of the elements in the roof trusses are: tie beams thick and large about 25 cm and thick about 20 cm, the length is 6.50 m. The rafters are long 3.40 m, large 24 cm and thick 16 cm, the king posts are large 24 and 17 cm thick. The whole truss is about 1.74 meters high.

The timber beams are square edged or wane edged. Crosses and other signs were engraved on structural wooden elements probably as assembly marks. Burglaries in tie-beams, rafter and king post are found which indicate a reuse of the wooden elements in epochs which it is not easy to suppose. The position of such burglaries in the king post seems to be related to the presence of ancient roof arrows, which now are not any more present in the structure.

PAINTING.

Santa Maria Nuova has one of the few painted roof on chestnut wood known in Italy. The decoration is on elements which have a structural function like purlins and joists so as on small planks (fig. 1) and the frame which encloses the fired clay tiles. The trusses are not painted. Red, green, white and black pigments are to be found in the wooden elements, their chemical

composition is to be still fully analysed, anyway in red pigments iron chemical element is found, in white there is chalk.

DECAY AND RESTORATION CRITERIA OF THE LOAD BEARING STRUCTURE

The restoration project consisted in a deep renovation of the roofing, removing all the roof, portion by portion, saving and checking each single component: painted tiles (fired clay tiles), painted steaks and planks, small painted purlins, rafters of the two aisles, joists, and the components of the trusses (king-posts, top-chords and bottom-chords). Many points of discussion rose during restoration works, in order to accurately assess the different damages and strength/stiffness properties of timber elements.

According to the main method and procedure established for the on site inspection [1], our strategy was to proceed with a mainly visual approach, examining carefully, one by one, each timber element for the whole length, starting from the ones with the largest cross section. For this procedure simple tools were used such as hammers, borer, screwdriver etc. Particular attention was given to portion of wood close or inside the wall, to verify possible decay. The dislodgement of the roof made it simpler and more effectiveness. The painstaking examination had two paramount purposes: a) the evaluation of the effective sound cross section, excluding decayed parts, b) the assessment of the appropriate grade of each timber member. These two fundamental data are always needed for a correct design of the restoration project. An appropriate visual grading rule was necessary to grade each ancient timber element. The Italian standard UNI 11119 [2], tested in on site grading from 2004 to nowadays with satisfactory results [3], showed a good applicability also in this project. The standard shows procedures, aims and requirements to conduct the technological on-site survey. The assessment of eventual decay or damage in the beams, for deducting the effective cross section, unacceptable in freshly sawn timber, is currently applied on ancient timber structure, because it is always possible to know in advance the actual loading conditions and therefore the stresses along the beam.

In the study case the species used showed its great advantages: Chestnut is a very durable wood (class n.2 of natural durability according to EN 350-2 [4]), insect attack (mainly by Anobidae family) is located in the external parts of the beams in the thin layer of sapwood.

Sometimes rot decay has been found in the top- and bottom-chords in the portion inside the wall: possible high moisture, and low oxygen content, during the life period of the roof, have promoted rot decay. In such situation there is the possibility that the heel of the tie beam, which prevent the top-chord slip, is totally destroyed and a roof failure is resulting.

Restoration criteria were pointed out in order to lead the choice towards more reversible and compatible operations which are also more respectful of original wood. According to the Italian Standard knots, slope of the grain, ring shake presence were assessed and located on the structure so as to assign each element to the visual grade.

The tie beams of truss 1, 8 and 9 were restored using new wooden portion (fig. 3), using a more friendly and reversible restoration system respect to the original restoration plan which provided only for the use of epoxy resins. Then epoxy resins were used only when higher structural performances of timber elements were necessary according to the restoration design of the architect.

Some wood repaired ends, structurally connected, like “dardo di Giove” (fig. 4) are well known and assessed in restoration of wood load bearing structures. The restorers proposed also some interesting not common solutions: e.g. new beam portion, connected through a "swallow-tailed" joint, with bolts and resin; it seems to have all the characteristic to solve the possible tension value, expected in the tie beams. Further laboratory tests are planned to verify the effectiveness of the new joint proposed.

DENDROCHRONOLOGICAL ANALYSIS

Dendrochronological analysis has allowed to build a mean curves using the old joists and small beams which were replaced during the restoration works.
The mean dendrochronological curve is 135 years long, it contains 32 single dendrochronological curve. Furthermore coring was performed on the roof to verify if the painted structure is contemporary to the load bearing one. The results show as the curves of the chronology do not synchronize so well with the cores taken from tie beams, rafters, king posts and roof pillows.
The interpretation of this result might be related to different hypothesis:

- wood belongs to different ages
- wood is dated in the same period but it comes from different geographic areas. By this point of view we cannot neglect that chestnut synchronization in dendrochronological analysis is not so easy even when trees of very close sites are compared [5]. Dendrochronological analysis was performed according to UNI 11141 [6]. Absolute dating of wood elements will be assessed by means of wiggle matching procedure which combines dendrochronology and radiocarbon method.

FURTHER LABORATORY ANALYSIS

Because wood diagnosis is very important before restoring, comparison between resistograph profiles and wood characteristics such as ring width and density are going to be performed. The task is to make accurate as much as possible the instrumental analysis which is used in the inspection before the restoration. This part of the research is strictly related to the inspection in situ of wood defects on the load bearing structures. This kind of analysis is still a work in progress.

CONCLUSION

Santa Maria Nuova roof can be considered an example of different practices which might be used in roof restoring. The special position occupied by this roof is due to the fact that painted chestnut, in our knowledge, is very rare to be found. A further element which must be considered important is that firstly in Viterbo, in this roof, many different expertise such as wood technologists, painting restorers, timber structure restorers, architect, Sovrintendence, ownership etc. were able to interact and in some cases to cooperate for the promotion of good practices in ancient timber structures restoration. This must be observed as e further step towards assessing the new figure of wood technologist as expert in timber for structure, in which the new generation is investing.

Project financed by University of Tuscia,, University of Florence, Fondazione Carivit, Arch. Luca Melappioni and Giovanni Profili firm.

REFERENCES

[1] Bonamini G., M. Noferi, M. Togni (2001). *On-site grading of old timber members*. In: AAVV. Wooden Handwork/Wooden Carpentry: European Restoration Sites, pp. 205-210, Paris, ISBN:9782842993443.
[2] UNI 11119:2004. *Cultural Heritage – Wooden artefacts. Load-bearing structures. On site inspections for the diagnosis of timber members*.
[3] Mannucci M., Brunetti M., Macchioni N. (2011). *The Italian standard UNI 11119:2004 for the in-situ diagnosis of timber structures: pros and cons after 5 years of practical application and proposals for emendations*. Proceedings of SHATIS'11 International Conference on Structural Health Assessment of Timber Structures Lisbon, Portugal.
[4] EN 350-2:1996 *Durability of wood and wood-based products. Natural durability of solid wood. Guide to natural durability and treatability of selected wood species of importance in Europe.*

[5] Romagnoli M., Nocetti M., Sarlatto M., Evangelistella L., 2004. Dendrochronological assessment of chestnut (Castanea sativa Mill.) for dating purposes in Central Italy. Dendrochronologia, 21/3: 117-130

[6] UNI 11141:2004 *Cultural heritage. Wooden artefacts. Wood dendrochronological dating guidelines.*

FIGURES

Fig. 1 detail of the painted roof.

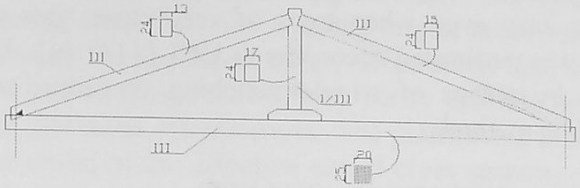

Fig. 2. Example of the schematic representation of chestnut 4th truss. Each timber member is graded (grade I, II, III) and the effective sound cross section is reported (data in cm).

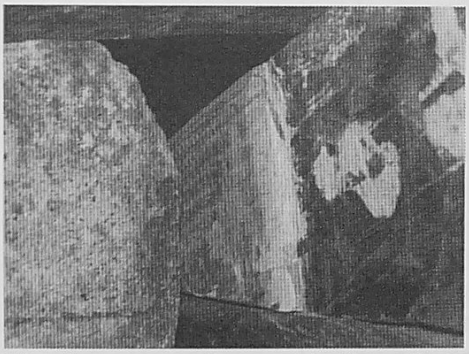

Fig. 3 new wooden part in the rafter of truss 1.

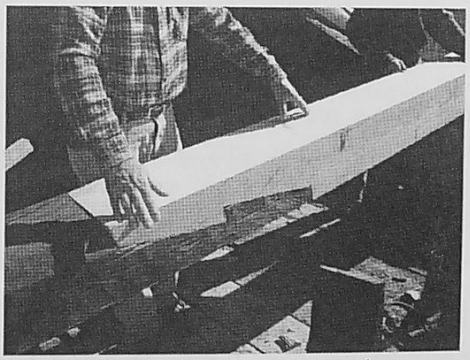

Fig. 4. The typical new wooden part with the shape "Dardo di Giove"

Fig. 5. Bar diagram of the mean chronology built in the church of Santa Maria Nuova.