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An investigation into preservation of wood from Venice foundations

Nicola Macchioni *, Benedetto Pizzo, Chiara Capretti

IVALSA-CNR, Firenze, Italy

HIGHLIGHTS

- Description of a methodology to sample wood from Venice foundations.
- Analyses to describe wood species constituting piles of Venice foundations.
- First results about the state of preservation of wood from Venice foundations.

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ABSTRACT

The present paper deals with wood from Venice historic centre foundation elements. Samples were taken from both piles and planking (horizontal elements positioned above the pile heads), in 5 out of 6 districts of Venice. Considering the watery milieu, the diagnostic methodology for waterlogged archaeological wood was adopted, performing anatomical, chemical and physical characterisations.

Our results show that the wood used for Venetian foundation elements belong to a small group of 5–6 species (alder, larch, oak, pine, elm and spruce, although the latter was probably of more recent introduction). Most of the analysed samples evidenced decay, which in some cases was high (residual basic densities of only 32%, and values of the ratio holocellulose to lignin as low as 0.3). It was evidenced how the state of preservation of wood was related to several factors, including: thickness of the element, depth of burial, horizontal/vertical position, and wood species. It was also shown how ash content does not reflect the state of preservation of waterlogged material, as it is sometimes reported in the literature. The diffuse decay was apparently not related to the general stability of the buildings under study.

1. Foreword

The foundation soils in Venice are composed of sand, silt, clay and peat which are often mixed in different proportions; all of these layers are relatively compact and show a low bearing capacity. For this reason, Venetians started to consolidate the soils underneath important buildings by using wood piles, inserted quite close one to another. The piles used in the foundation system belonged to different species, even if it is commonly thought that alder (*Alnus* sp.) is the most diffused one [7]. Piles usually had diameters varying from 10 to 25 cm: normally there were up to 9 piles per square meter; their pounding usually proceeded from outside towards the core of the foundation. Pile length ranged from a maximum of 3.50 m to less than 1 m [7]. Once the piles were pounded, their heads were sawed to get a regular surface, on which two or more layers of timber (laying perpendicular to the piles) were set. These were made of boards (*zatteroni*) or beams (*madieri*), their thickness depending on the weight they had to bear. Considering for example the case of bell towers, the total board thickness could be 50 cm or even more: the interposition of cross-boards above the palisade was conducive to homogeneous patterns of the foundation system as a whole [4].

Surveys on the Venetian bell towers of the churches of *Santa Maria Gloriosa dei Frari* and *Santo Stefano* suggested that the structural characteristics and the state of preservation of the foundations are pivotal to the static equilibrium of the entire building [2].

The foundation building system of Venice is quite well known [29,24]. Yet, scientific investigations into preservation of wood piles (constituting an important part of this composite system) are substantially lacking. For a long time it had been thought that wood immersed in wet mud was not subjected to any form of decay: since wooden foundations have sustained Venice for thousands of years, the wood immersed in mud was postulated not to decay. In fact, the complete imbibition and the chemical-physical and biological conditions in which wooden piles are preserved

* Corresponding author at: IVALSA-CNR, Via Madonna del Piano, 10, I – 50019 Sesto Fiorentino, Italy.

E-mail addresses: macchioni@ivalsa.cnr.it (N. Macchioni), pizzo@ivalsa.cnr.it (B. Pizzo), capretti@ivalsa.cnr.it (C. Capretti).

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thwart a rapid decay process, because the most aggressive biotic degraders do not easily act under such conditions. However, recent investigations carried out on wooden foundations (not only pertaining to the Venetian soil) evidenced a more complex situation. In particular, decay was shown in analyses performed in the Netherlands [14], and similar conditions were also found in the two aforementioned Venetian bell towers [2], although with some variability between the cases. These findings question the actual behaviour of the foundation system constituted by the combination of wood, soil and water [9].

To highlight the interaction among these three components and the state of preservation of the foundation system, a specific project was set up under the coordination of CORILA, a non-profit organization which includes several Public Bodies in Venice and is overseen by MIUR (Italian Ministry of Education, University and Research), and with the involvement, among others, of the Soprintendenza Belle Arti e Paesaggio per Venezia e Laguna (the Venetian authority for the preservation of Cultural Heritage) and of Insula (the public society in charge for the maintenance works in the Venetian canals), which provided support to sample the wood material.

The present work is aimed at reporting about the state of preservation of the waterlogged wood samples taken during the surveys on the pile foundations of some ancient buildings, located in five of the six districts (named "Sestiere" by Venetians) of the city. Thus, the results shown hereinafter refer to the first survey aimed to assess (through integrated analyses) the state of preservation of the Venetian foundation woodpiles, sampled on a large part of the historic city centre (Fig. 1).

Foundation piles represent structural elements still in service, that have not lost their original mechanical function. Due to their position, these elements are completely and permanently waterlogged. Hence, the adopted analyses were the same as those applied to assess the state of preservation of waterlogged archaeological wood.

2. Materials and methods

Samples were collected taking advantage of maintenance yards outside the canal system. The maintenance operations provide for drying the canal in order to gain access to the bank walls, re-sealing the banks and restoring the damaged walls. Therefore, the foundations of the bank walls are generally the only pretty accessible parts of the Venetian wooden foundations. In few cases (specified below), the maintenance works allowed to get samples from central portions of the foundations (geological coring to obtain 12-cm ∅ samples).

The sampling sites were located: one in San Felice, Cannaregio district (at the confluence of Rio dell'Acqua dolce and Rio dei Gozzi, points 1 and 2 in Fig. 1), two in San Martino di Castello (Rio Ca'di Dio, Castello district, point 3 in Fig. 1), the planking site of the Ponte della Paglia, close to the Duke's Palace (two boards), San Marco district (point 4 in Figs. 1 and 2). Lastly, two piles (extracted as entire portions from geological coring) were accessed from the foundation of the former Monastery of Santa Chiara, in Santa Croce district, close to the railway station (point 5 in Fig. 1). The details of the various samples divided for typology and for site are shown in Table 1. The sampling sites 1, 2 and 3 allowed to obtain wood samples (by both chisel and corer) only from the external piles of the foundations. In sites 4 and 5 also the internal foundation piles were sampled through geological coring.

Except for the Ponte della Paglia, whose enlargement dates back to 1854, it is practically impossible to establish the age of the foundation system in the sampling areas. Although historical analyses can determine the age of the first stable settle-

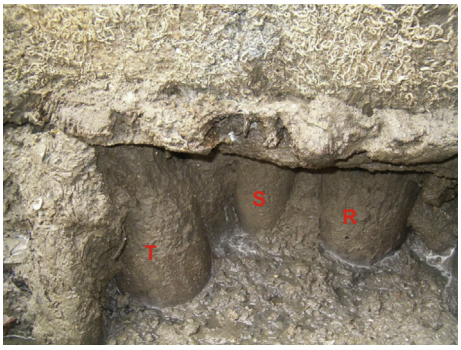

Fig. 2. The three poles sampled at San Martino.

Fig. 1. Map of Venice showing the sampling sites: (1) Rio dei Gozzi, (2) Rio Acqua dolce, (3) Rio San Martino, (4) Ponte della Paglia, (5) Santa Chiara (image adapted from Google maps). Also reported in the map are the locations of the belfries of Frari (6) and Santo Stefano (7) churches, frequently quoted in the paper.