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Original article

An integrated approach to the conservation of the roofing structures in the Pompeian *Domus*

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ABSTRACT

The structural restoration interventions in the archaeological site of Pompeii have been performed since the beginning of excavation in the area. In the last century the old wooden roofs erected in the late 1800s were replaced with concrete structures similar to the old ones, realized after the Second World War. A systematic study of these structures is lacking, despite the number and the significant role they play in the stress state of the ancient masonry. The structural role of these roofing structures in the Pompeii buildings and atriums and in the suburban Villas is examined. Starting from a detailed geometrical and historical analysis of the roof, the impact of the restoration interventions actually present in the archaeological area of Pompeii is analyzed in order to assess the seismic vulnerability of the buildings and the key aspects in case of restoration or maintenance. The paper shows that maintenance of the existing interventions is a fundamental topic and substitution of r.c. roofs with timber structures cannot be justified with structural reasons. As a case study the entire structure of the *Domus* of the Tragic Poet (masonry walls and concrete roof) is investigated.

1. Introduction

Archaeological constructions have rarely come down to us in their original configuration: they have almost always been profoundly altered by successive mutilations and transformations, giving them a new configuration and state of equilibrium as ruins. In some cases strong interventions have been made in order to rebuild the original construction. This makes archaeological remains the object of complex, interdisciplinary studies involving archaeologists and applied scientists [1]. Unfortunately archaeological sites have been subjected to many ill-considered, invasive interventions in the name of conservation in flagrant contrast with the ancients' construction culture. This was especially the case during the second half of the 20th century, thanks to post-war reconstruction and the boom in house building [2]. Moreover, some restoration projects have been closer to an architectonic reinterpretation of the ruins than a scientifically grounded reconstruction. Several interventions were made by reinforced concrete (r.c.) and actually the scientific debate is mainly about opportunity and durability of these interventions [3,4]. Apart from the problems linked to the time-dependent damage of concrete [5], another question regards the variation of vulnerability and in general the static impact of these interventions on the ancient masonry structures [6], as the recent collapse of the *Schola Armaturarum* testifies.

The first structural interventions in many Pompeian *Domus* involved the replacement of old wooden roofs with concrete structures similar to the old ones. Several of these roofs realized in particular on the atriums are nowadays visible.

Emblematic case is the Vettii *Domus*, in which in the structure in r.c. [7] was badly structurally flawed and was done using an inferior concrete, so that due to its very bad conditions [8] it was removed and substituted by a timber one. In other cases, like the Tragic Poet *Domus*, the atrium roof is in better conditions.

In general the approach to the analysis and interventions on archaeological heritage should be carefully calibrated [9]. A Pompeian atrium is only a limited part of the complex structure of the *Domus*, so that the cultural discussion about the quality and scheme of the roof cannot be set apart from the structural analysis of the whole structure of the building. In other words the key issue is the influence of the material chosen for the roof on the ancient masonry stress state and durability [10], since the archaeological parts of a Pompeian *Domus* are the remaining walls of the building [11].

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This paper deals with this last aspect, showing the results of a finite element analysis on the whole Tragic Poet *Domus*, to assess the influence on the ancient masonry walls of two distinct materials for the roof. The constitutive model chosen for the building materials is the linear elastic one. The model adopted is elementary; nevertheless it is suitable for the scope of the paper. Closer descriptions of the behaviour of the structure could be obtained by considering the essential unilateral behaviour of masonry [12,13]. The first part of the paper is devoted to the history of the roofing structures, showing the determinant role of the excavations on the interpretation of the static schemes. The uncorrected pre-excavation structural hypotheses are discussed too. The second part of the paper deals with the structural dynamic analysis of the whole Tragic Poet *Domus*, discussing the influence that the two different construction techniques analyzed for the atrium have on the stress state of the Roman masonry.

2. History of the roofing structures of the atriums

Before the discovery of Pompeii the structures of the houses were unknown, so that Vitruvius' third chapter of sixth book make sense only after the excavations. A simple comparison of pictures in the editions of *De Architectura* before and after the Pompeii discovery is clarifying [14]. The analysis of the pictures relative to the third chapter of the sixth book about the five types of atrium in the first printed version of *De Architectura* compared with those realized after the Pompeii discovery gives significant indications.

The Vitruvius treatise has survived thanks to only one copy without illustrations, so that all the researchers that contributed to its diffusion since XV century tried to translate the written content into pictures.

Vitruvius gives a description of five types of atrium (tuscanicum, tetrastylon, corinthium, displuviatum and testudinatum). As an example, the Tuscanic atrium in the first XVI century version of the treatise [15] quotes: "Cava aedium quinque generibus sunt distincta, quorum ita figurae nominantur, tuscanicum, corinthium, tetrastylon, displuviatum, testudinatum. Tuscanica sunt, in quibus trabes in atrii latitudine traiectae habeant interpensiva & colliquias, ab angulis parietum ad angulos tignorum intercurrentes, Item asseribus stillicidiorum in medium compluvium deiectus" and the pictured version is that in Fig. 1, left, while the same Vitruvian description in a successive version of the treatise dated 1521 [16] gives a different result (Fig. 1, right).

The picture in these versions of the Vitruvian treatise, like several others before the Pompeii discovery, are a representation of an unknown reality, therefore reference is made to contemporary architectures of the time. In the illustration by Cesariano [16] doors and windows mouldings refer clearly to Renaissance style, strongly different from the real Pompeian architectural elements.

The importance of the discovery of Ercolano and Pompeii stands out: the XIX century drawings, generally based on the results of excavations are in many cases suggestive [17,18]. An example is reported in Fig. 2.

Some versions of *De Architectura* report as illustrations of the ruins just the Pompeian *Domus*. In the initial phase of the excavation of Pompeii in the middle XVIII century the access at the archaeological area was difficult, due both to the incomplete removing of the volcanic materials and to the Royal Decrees. On the basis of

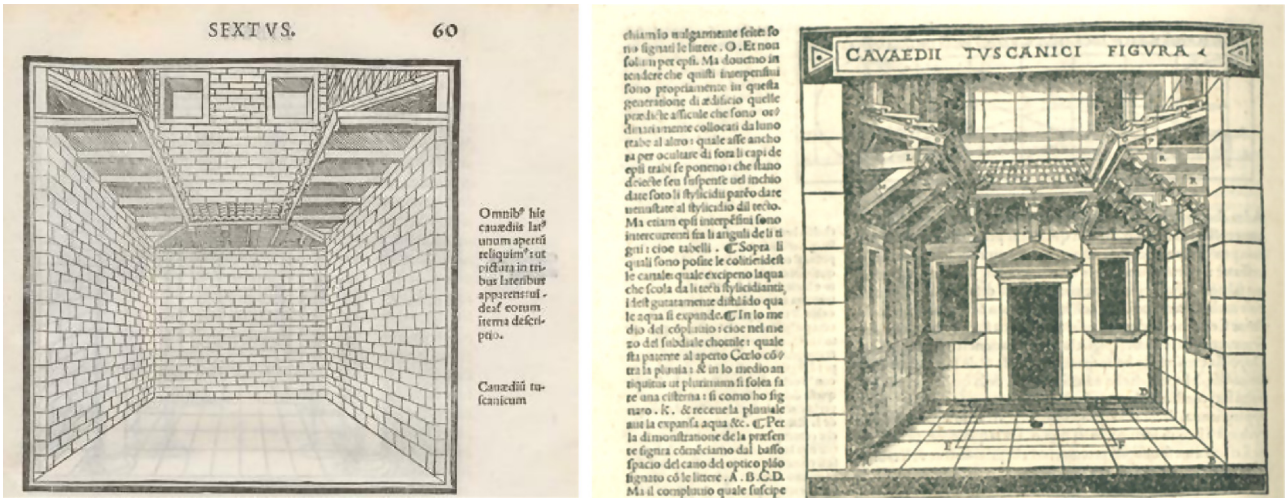

Fig. 1. Tuscanic atrium according Ioannes Iucundus, 1511 [15] (left), and according Cesariano [16] (right).

Fig. 2. The House of the Tragic Poet (left), watercolor lithograph [50], reconstruction of the House of the Tragic Poet atrium [58].

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