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In copertina: Nora, veduta della penisola da est (cortesia Consorzio Agenzia Turistica Costiera Sulcitana - STL Karalis, foto Ales&Ales)

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Università degli Studi di Padova
via 8 febbraio 1848, 2 - 35122 Padova
tel. 049 8273748, fax 049 8273095
email: padovauniversitypress@unipd.it
www.padovauniversitypress.it

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Quaderni Norensi

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Indice

A methodology to the reconstruction of archaeological building remains. The case study of the Roman building in the eastern district of Nora

Anna Maria Giatreli

Abstract:

The discovery of building remains in the eastern part of the Roman settlement in Nora, dated back to the first phase of the imperial era, introduced new information and challenges regarding the understanding of the evolution of the ancient site. The aim of this work is to propose a reconstruction hypothesis for one of the rooms of the building, Room III-XIII, through a multidisciplinary approach that combines complementary sources of information and knowledge from the fields of Archaeology, Engineering and Material Science.
Combining different sources of information, decisions were made for the floor configuration and the beam orientation, the spacing and shape of the beams, the roof configuration, the loads, the inclination and the pitch orientation. The result was to come up with 3 different configuration scenarios, with the existence of a main floor beam and a roof purlin supported by a masonry column being the most probable.

Lo scavo dell'edificio romano nel settore urbano ad est del foro di Nora, datato per la fase d'impianto alla prima età imperiale, ha fornito nuovi dati e spunti utili alla comprensione dell'antico centro norense.
Questo contributo mira a proporre un'ipotesi ricostruttiva per uno dei settori del complesso (vani III, XIII), mediante un approccio interdisciplinare che combini fonti di informazione complementari e conoscenze acquisite in ambito archeologico, ingegneristico e delle scienze dei materiali.
Questo metodo combinato, ha permesso di proporre vari assetti possibili per il pavimento del primo piano, per l'orientamento, la disposizione e la forma della travatura, per la configurazione del tetto, per i carichi, l'inclinazione e l'orientamento della falda. Si è giunti a 3 distinti scenari ricostruttivi possibili: il più probabile prevede una trave maestro e travetti rompitratta, sorretti da una colonna in muratura.

Introduction

The reconstruction hypothesis of one room of a Roman building recently found in the archaeological site of Nora, Sardinia is described in the present study. By describing the basic steps of the procedure, the aim is to attempt the definition of a reconstruction methodology.

The studied Roman building is probably dated back to the first phase of the imperial era, between the end of 1st century B.C and the first half of the 2nd century A.D, and underwent through a vast renovation at the end of the 3rd century A.D, around 282 A.D.[1].

[1] Asolati, Bonetto, Zara 2018.

Step 1: Archaeological survey

The archaeological survey, meaning the analysis of the structure's remains, is the first important step in the process of identification of the original morphology of the building. Archaeological sources are used to identify the arrangement of the structural elements, the use of the building, its context, surroundings and complexity, as well as the reason of its collapse.

1.1. *General arrangement of the building - Collapse hypothesis*

The archaeological survey of the Roman house in the eastern district of Nora revealed a distinct division between east and west sectors. The division is marked by an elongated hallway and the western sector of the building was at a lower level. Apparently, the building was built in phases and perhaps its use was varying along the years, as well as the level of wealth of its occupants. Signs of wealth are the remains of wall decorations found in Room VII and VIII in the eastern sector and also the money bin found in the hoard at the end of the hallway towards north (room IV). There are no similar signs of wealth in the western sector, which also appears to be more carelessly constructed[2].

The archaeological survey also brought to light floor fragments lying on top of the ground floor remains proving the existence of a second floor. According to the excavation findings so far, a second floor existed only above Room III and XIII. Similarly, broken roof tiles on the ground level indicate the existence of a roof covering on top of the room. Another sign of open space is the typical brick pavement of outdoor spaces, which was found in room IV. The general arrangement of the Roman house under study is shown in figure 1 (fig. 1).

Last but not least, a collapse hypothesis is based on archaeological studies. The dominant scenario is that the collapse occurred due to the abandonment of the house and its gradual degradation. First, the higher parts of the walls in raw material began to deteriorate, as evidenced by the accumulation of bricks in decay, fragments of plaster and binder at the base of the masonry, later the statically compromised structure, underwent permanent deformations that caused its collapse[3].

1.2. *Identified structural and non-structural elements*

The building remains brought to light consists of stone blocks extending about 1m over the floors. These limestone and andesite blocks binded with lime mortar (*opus caementicium*), are part of the ancient wall, which was a mixed structure. Above the stone blocks, there was probably a mudbrick masonry structure, which is not preserved.

An important feature of Room III is the existence of a rectangular plinth base, which is probably the base of a masonry column, whose mortar trace of the base circumference has been identified. In addition to the plinth base, a rectangular pit at the south wall of the room is associated to the stairs that led to the upper floor.

According to archaeological findings, the ground floor pavement was casted on top of the plinth base, hence it is quite logical to assume that the excessive deflection of the floor was expected and the column was added at construction stage to prevent it. The plinth base is located at approximately the centre of the room, considering that there is a second internal wall in the room that is not a perimeter wall, because it is quite slender and made of poor-quality masonry, with shapeless blocks bound with clay mortar. As a result, it very unlike that this wall is a load bearing wall.

Step 2: Material Analysis

A large sample of the second floor of Room III, over 10cm thick, that was recovered during the excavation campaign of 2018, has been petrographically, mineralogically and micro chemically analysed in order to identify and describe the inner stratigraphy and composition of each layer. In addition, the compressive strength of the piece is determined through mechanical tests and the density is calculated.

The information from the analysis of the second-floor fragments were used to define the loads imposed on the struc-

[2] Di Maio *et alii* 2018; Zara 2018; Volpin, Zara in this issue.
[3] Zara 2018.

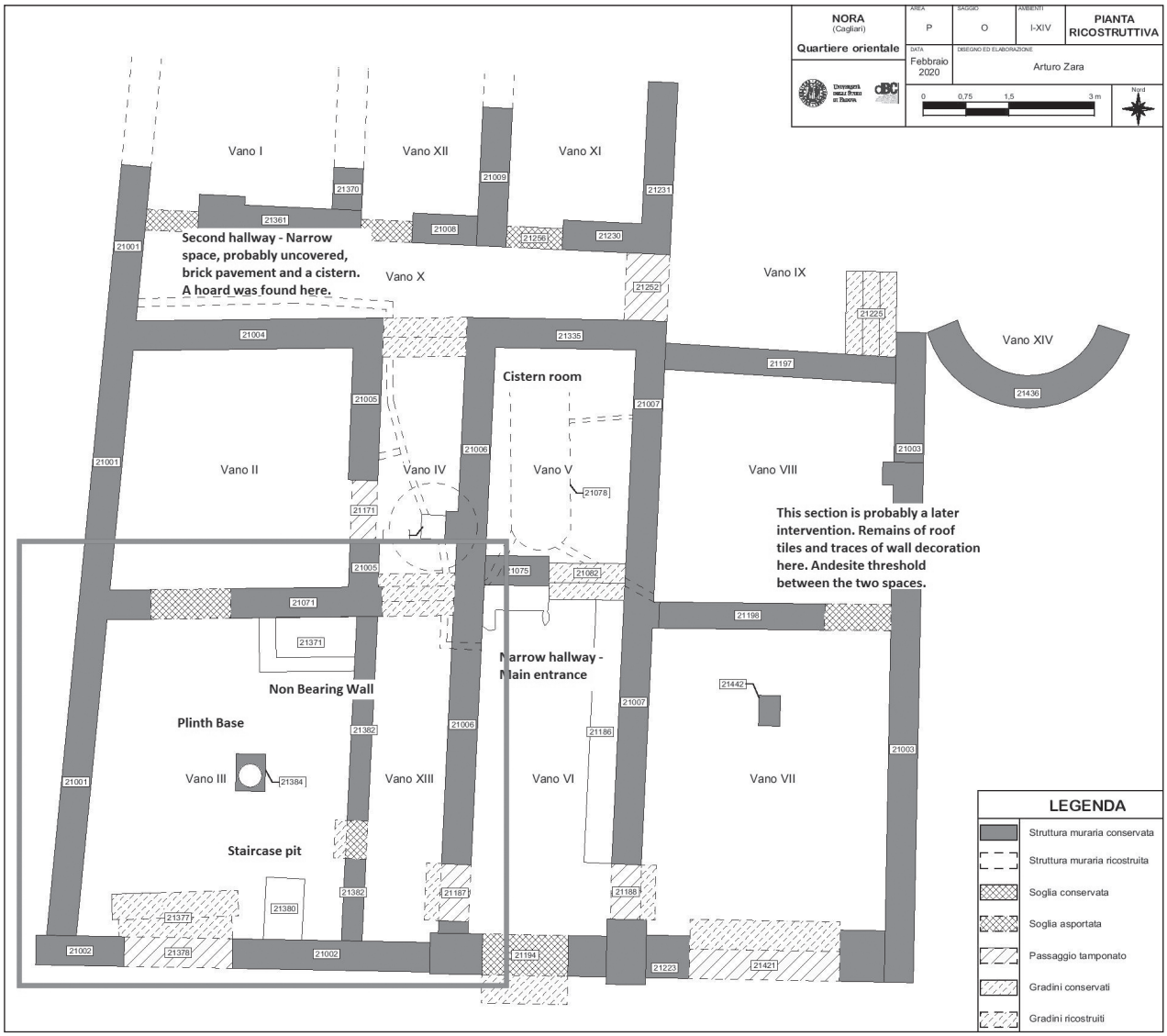


Fig. 1 - The plan of the Roman building in the eastern district of Nora. This paper focuses on the rooms in the box highlighted.

tural members. In addition, the material analysis is anticipated to contribute to the conclusions for the use of the second floor, the type and complexity of its construction.

In general, the material analysis revealed that the piece has the typical composition of a Roman concrete pavement with broken terracotta fragments, layered in a unique stratum, with a superficial compacted layer due to polishing and smoothening of the external surface. The abundance of lime binder, homogeneously mixed with aggregates, determined a 1:1.5 B/A ratio. This demonstrate good technical skills of crafts. Probably, in an attempt to reduce the weight, mainly porous terracotta fragments are used as aggregates, which are lighter than lithic elements, with secondary rock fragments and sand. The analysis confirms that the pavement in composed of an aerial concrete with no substantial pozzolanic reaction products. Therefore, it can be assumed that the floor was not intended to be exposed to weathering. The absence of pozzolanic reaction, related to hydraulic mortars, is proven among others by the SEM analysis and by the existence of completely distinct phases, separated and without reaction products in their interface (fig. 2).

Step 3: Historical Review / Local features

Having a reference point during the process of identification of the building typology and identity is crucial when making decisions and can be the decisive factor for accepting or rejecting a specific solution. Ideally these references are structural remains of similar buildings located on the surrounding area and constructed during the same period of time.

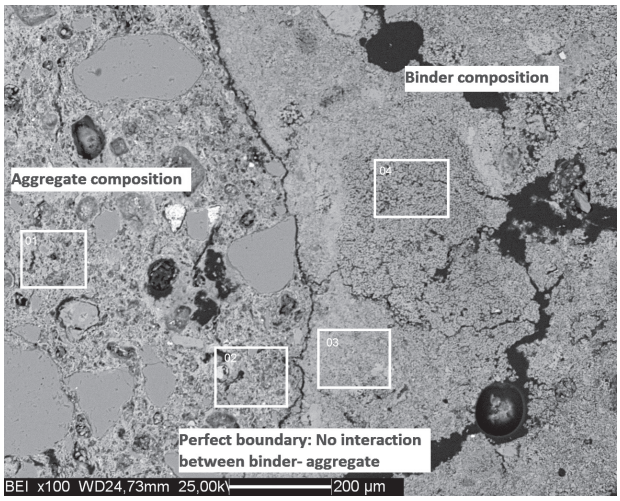


Fig. 2 - SEM analysis results proving completely separate phases in the mixture.

In reality, these cases are rare, so compromises and hypothesis need to be made. Apparently, space and time are the two important parameters, sometimes one prevailing over the other. If two structures are constructed in different periods, the geographic proximity, although important, it is not so useful. This is supported also, in the cases of large empires with proven efficient transportation and communication system within the huge empire lands. On the other hand, since the construction techniques is strongly tied to the environmental conditions of a place, especially in times of scarcity of resources, traditional construction techniques are proven extremely consistent over time.

In the case of the Roman building in Nora, unfortunately there is not enough information about the construction details of residential building with mudbrick walls in Nora, or even in the Roman Sardinia. Other sources of information about residential building typologies in other parts of the empire and of different periods should be carefully used. Although, the Romans developed a uniform organisational system throughout their enormous empire, affecting all aspects of commercial and everyday life, even construction techniques, and although it is proven that there was a well-organized trade system which enabled the unlimited circulation and exchange of the Roman products through the whole empire, the effect of local conditions and traditions should not be neglected. This effect is becoming more significant in case of common private houses of a poor background which were more carelessly built.

In order to overcome these difficulties, complementary sources of information are considered. First of all, modern constructions in Sardinia based on traditional materials and techniques are studied[4]. The characteristic of the traditional houses in Sardinia is the simplicity and the fact that they reflect local needs and traditions render these typologies diachronic. Additionally, other archaeological sources are used, mainly studies upon Pompeii and Herculaneum, which are studied extensively in the past and provide large amount of information upon the Roman building typologies and construction features. The key issue is that all the information is evaluated and they are either accepted or rejected based on whether they agree or contradict the archaeological findings.

Step 4: Structural analysis / Engineering judgement

The final step, which is anticipated to fill in the gaps in the reconstruction hypothesis and provide the final solution is the structural analysis, based on engineering calculations. Knowing the collapse mechanism, either structural or not, and basic dimensions of the structure, the structurally admissible size of the principal elements can be determined. Of course, structural analysis is a complex procedure based on not just one formula and requires various assumption on material properties and structural behaviour. Thus, again it is up to logical assumptions of the level of knowledge of the ancient builders and the importance of the structure that define the level of simplification of the engineering calculations. For example, material properties that are quite apparent, such as creep deformation of timber, was most probably known in antiquity and this parameter can be safely used in the calculations, without the risk of optimising beyond acceptable levels. The final decision, though, is still a combination of all the information and factors, such as, complexity, availability of materials, traditional techniques, archaeological data and the proposed solution is unavoidably parametric. In the case of Room III, decision was made for the floor configuration and the beam orientation, the spacing and shape of the beams, rectangular or circular, the roof configuration, the loads, the inclination and the pitch orientation. As for the material properties, the type of wood used as building material was critical. The possible wood types determined the range of the material stiffness and strength. The acceptable values had to be defined also. If the collapse was structural failure, the definition of a lower bound would be straightforward. This is not the case of the Roman house in Nora, so an upper bound is determined based on admissible deformation levels, because timber elements can deform significantly without losing much of their strength, so normally, they become unusable prior to collapse. The results of the structural calculations and the final dominant scenarios are shown in Figure 3 (fig. 3), the first case being the most probable[5].

[4] Atzeni *et alii* 2009; Ortu *et alii* 2009; Sanna, Atzeni, Musso 2009.
[5] Centola 2017-2018; Sbrogiò 2015-2016.

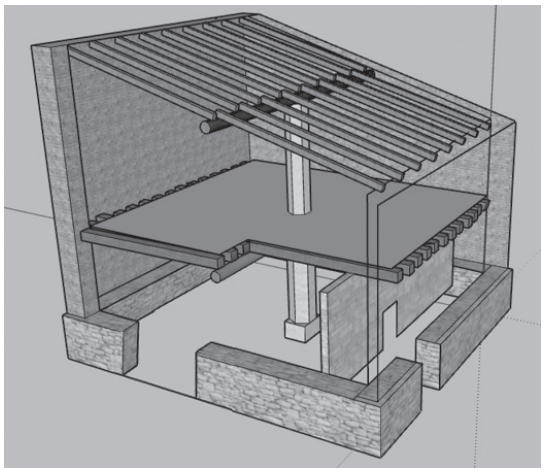
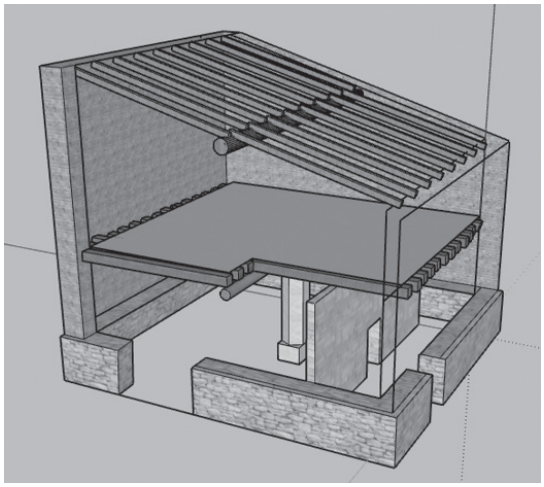
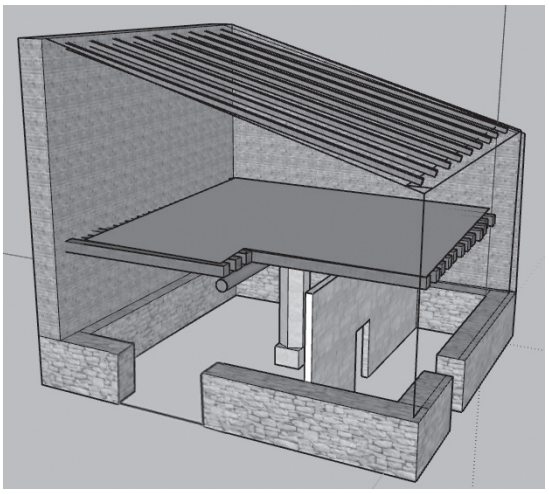
	***Floor*** • s = 0,3 m • Square section 20*20cm • hmin = 14 cm • Main beam : circular section 17 – 21 cm diameter ***Roof*** • Rafters: ≈ 12 cm • Purlin: 13 – 17 cm, square or circular
	***Floor*** • s = 0,3 m • Square section 20*20cm • hmin = 14 cm • Main beam : circular section 17 – 21 cm diameter ***Roof*** • Rafters: ≈ 12 cm • Purlin: 17 – 30 cm, rectangular
	***Floor*** • s = 0,3 m • Square section 20*20cm • hmin = 14 cm • Main beam : circular section 17 – 21 cm diameter ***Roof*** • Rafters: 12 – 20 cm

Fig. 3 - Reconstruction proposals according to the structural analysis results.

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