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A DATASET FOR 3D RECONSTRUCTION OF CENTRALLY PLANNED BUILDINGS FROM THE ROMAN AND LATE ANTIQUE PERIODS

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Abstract: 3D reconstructions have become an efficient research tool for archaeology that permits scholars to visualize and study different hypothesis simultaneously. This paper will examine the methodological choices that led to the creation of a dataset containing elevation and plan measurements of centrally planned buildings in roman and late antique period. By comparing the proportions of these structures, it's possible to gather a set of common ratios that are helpful for reconstructing the volumes of these types of buildings. The dataset is presented as a CSV file, including spatial coordinates and metrological information about the proportions of 25 buildings constructed between the 1st and 6th centuries CE. Although the collected data are already present in paper form within the final appendices of several publications, the usefulness of this work lies in making these data more readily available and searchable. The creation of this types of datasets has the potential to speed up the reconstruction procedures and provide a more precise evaluation of reconstructive hypotheses through a wider range of comparative data. An illustrative case of the dataset's practical application is demonstrated through its utilization in the reconstruction process of the hexagonal building at Villa dei Vetti. The paper will outline the dataset's attributes, the data acquisition methods and it will clarify how the collected information can be utilized in the field of 3D reconstructions of centrally planned buildings.

Keywords: virtual reconstruction, centrally planned buildings, late antiquity, 3D modelling, digital archaeology

1. Introduction

3D virtual reconstructions are widely acknowledged as a valuable tool for analysis and research in the field of archaeology. The progress made in this area has led to the development of a methodology that provides full transparency in the reconstruction process (Demetrescu & Ferdani, 2021). When reconstructing archaeological contexts in 3D, it is typically necessary to collect a substantial amount of information about the site under investigation. In addition it has to be considered data collected from comparable archaeological sites and derived from written sources. As a result, the use of shared and standardized methods is increasingly crucial to ensure the accessibility and utility of archaeological research. This contribution aligns with these principles and serves as an initial step in creating datasets specifically aimed at facilitating comparisons for 3D reconstructions.

The dataset being presented here was created as part of the process of the 3D reconstruction of the hexagonal structure of the villa dei Vetti, which is located close to Capraia and Limite, Florence, Italy (Cantini & D'Antoni, 2023). The objective of this collection was not to establish specific examples to be used with the case study, but rather to offer a number of parallels that would enable to reconstruct how ancient architects proportioned centrally planned buildings' volumes. For that reason, a dataset with the floor plans and height ratios for a collection of 25 centrally planned buildings (tab. 2) built between the 1st and 6th centuries CE was created. The dataset was organized as a CSV file. The methodology used for determining the plans and height proportions will be made clear in the section that follows as we take a closer look at the data structure. After that, we'll concentrate on the data collection process. In the final section we will examine the assumptions that can be made from this data collection and how these information can be utilized in the field of 3D reconstructions of centrally planned buildings.

2. Database structure and methodological approach

The dataset is divided into 4 sections (tab. 1), which differ in the type of information collected:

– 1st Section: provides qualitative information about the building, which allows the structure to be framed chronologically and functionally;
– 2nd Section: provides quantitative information about the building, such as the plan and elevation proportions of the structure;
– 3rd Section: provides the bibliographic details that allowed the dataset to be created;
– 4th Section: provides the information needed to frame the building geographically.

NAME	TYPE	DESCRIPTION
1st Section		
id	integer number (*integer*)	incremental identification number
name	text (*string*)	name of the centrally planned building
date min	integer number (*integer*)	oldest chronological indication in numerical value attesting the construction of the building
date max	integer number (*integer*)	most recent chronological indication in numerical value attesting the construction of the building
century	text (*string*)	textual chronological indication
sides	integer number (*integer*)	sides of the building; for circular structures, 0 was used.
vains	text (*string*)	type of side vains present in the buildings
function_1	text (*string*)	category by building function

NAME	TYPE	DESCRIPTION
function_2	text (*string*)	specific building function
2nd Section		
unit	text (*string*)	ancient unit of measurement
int_diam	integer number (*integer*)	inner diameter in meters
int_diam_f	integer number (*integer*)	inner diameter in the ancient unit of measurement (measurement transformation without rounding)
int_diam_if	integer number (*integer*)	ideal measurement of inner diameter
out_diam	integer number (*integer*)	outer diameter in meters
out_diam_f	integer number (*integer*)	outer diameter in the ancient unit of measurement (measurement transformation without rounding)
out_diam_if	integer number (*integer*)	ideal measurement of outer diameter
p_ratio	text (*string*)	ratio in plan between inner and outer diameters
w_thk	integer number (*integer*)	thickness of the masonry
w_thk_2	integer number (*integer*)	thickness of the outer masonry, is used only if the building has a "double shell" plan
i_width	integer number (*integer*)	inner width in meters
int_h	integer number (*integer*)	height of the central room
int_h_f	integer number (*integer*)	height of the central room in the ancient unit of measurement (measurement transformation without rounding)
int_h_if	integer number (*integer*)	ideal measurement of height of the central room
h_ratio	text (*string*)	ratio between the width and the height of the inner hall
w_h_ratio	text (*string*)	ratio between the thickness of the masonry and to height of the inner hall
ceiling	text (*string*)	field to indicate the type of roofing
3rd Section		
title	text (*string*)	title of the publication from which the information was taken
in	text (*string*)	name of the Journal or Conference where the article appeared
author	text (*string*)	author of the publication
year	integer number (*integer*)	year of publication
pg	text (*string*)	pages of the publication
4th Section		
mun	text (*string*)	municipality in which the building is located, for Italian ones the province is indicated in parentheses.
country	text (*string*)	state in which the building is located
X	decimal number (*real*)	geographic coordinates of the building in decimal degrees
Y	decimal number (*real*)	geographic coordinates of the building in decimal degrees

tab. 1. Explanation of the fields of the dataset "centrally_planned_buildings".

All measurements, both in elevation and plan, are shown in the 2nd Section (tab. 1). We will briefly go into the methodological principles that governed the creation of these metrics inside the dataset in the section that follows. The roman foot and the byzantine foot are the two recognized units of measurement. Roman and byzantine feet had conventional lengths of 0.296 m and 0.32 m respectively (Salvatori, 2006).

In some cases, the term "roman foot" may be followed by an asterisk (*), indicating a different intended standard value. In these circumstances, the standard value should have been 0.2995 m for a single asterisk and 0.295 m for a pair of asterisks.

When a building's rooms have central symmetry, it is said to be centrally planned. The studies carried out by Jones (Jones, 2003) on Roman and Late Antique centrally planned buildings have made it feasible to show how these constructions were frequently dimensioned in plan by using round measurements, that is, multiples of 10, 12, and 16 feet (roman or byzantine). These rounded measures were found by examining the diameters of the structure's inscribed or circumscribed circumferences. The decision of the ancient architect to draw these circumferences from the inner corner, the outer corner, or the middle of the masonry corresponded to a different static option.

Some of the centrally planned buildings contain more than one ring (polygonal or circular), both of which are specified by round numbers and connected by arithmetic proportions. The dimensions of the diameters that characterize the outer shells of this building type are therefore contained in the out_diam field. When it was feasible, the masonry thicknesses of the two rings have been provided for these double-shell constructions.

The overall height of these constructions, whether polygonal or circular, is frequently determined by the central room. As a result, when examining the elevations of centrally planned buildings, the size of this room is frequently used as a starting point (Johnson, 2018). The inner volumes of these buildings changed from Roman times to Late Antiquity. The main hall's spatial unity progressively lost way to ambulatories, standalone rooms, and niches (Bettini, 1978, pp. 62-87). In order to help with the analysis of the elevated proportions to recreate the interior space as experienced by an ancient visitor, the internal width (i_width) of the building, measured from the internal corners in the case of polygonal conformations, and the full height (int_h), calculated from the internal floor level to the ceiling, were listed. The fields related to the height sizing of structures (int_h, int_h_f, int_h_if) were given the value 0 when the building no longer retains its original elevations. Additionally, a field has been set aside to describe the technique for construction and type of roofing of the central room, as well as to identify, in the event

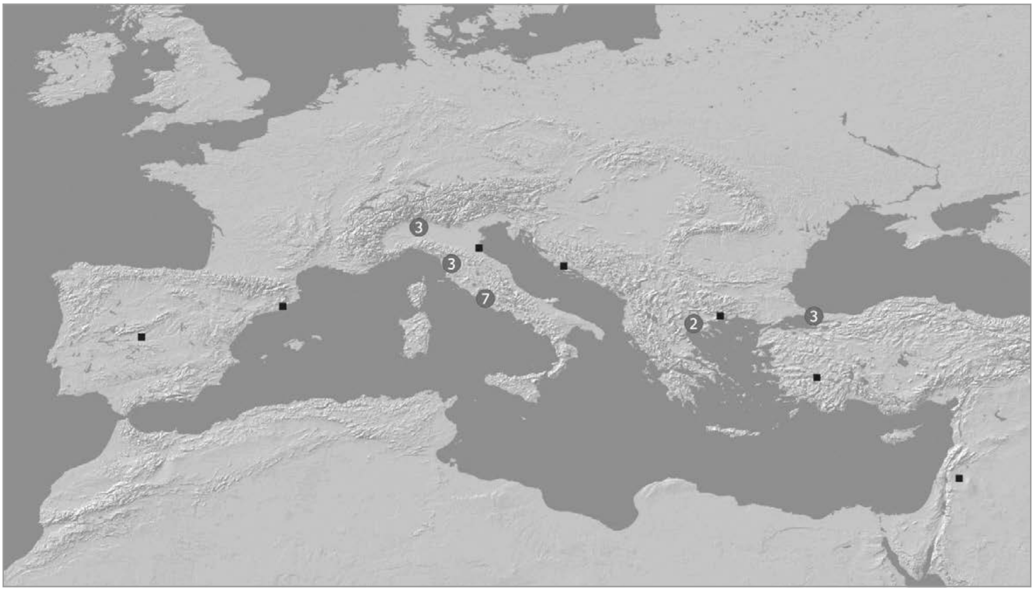

fig. 1. Location of centrally planned buildings.

of buildings that do not maintain the original elevations, the most reputable roofing hypothesis (the prefix "hp-" is placed before the roofing).

3. Data collection

The data collection process followed a simple methodology. Whenever possible, the necessary information for creating the dataset was extracted from the publications listed in the dataset. This information was found either within the main text or in tables and appendices at the end. In cases where some essential details were absent from the text itself, we deduced them by referring to available plans, sections, and prospectuses. Throughout all of these procedures, measurements were obtained by importing these structure representations into AutoCAD and then extracting the desired measurement. The geographical (fig. 1) and chronological range (1st-6th century CE) was selected to highlight prevalent practices in Roman and Late Antique construction, particularly emphasizing the use of simple arithmetical and geometrical proportions. Despite of the heterogeneity of the structures throughout the sample emerged a common volumetric sizing approach (fig. 2). Many of the buildings examined can be traced back to commissioners who were part of the imperial entourage, and who likely must have been inspired by common models when selecting the building layout.

4. Conclusion

In this last section, we will see how the data collected can be used during the reconstructing process of the volumes of centrally planned buildings. The starting point in this type of study is the recognition of the ancient unit of measurement. The Roman foot was found in most of the surveyed buildings, while the Byzantine one was found mainly in the eastern part of the roman empire.

Afterwards, it is necessary to determine the building's plan proportions. Most of the round dimensions defining interior rooms (int_diam) are between 10 and 20 m, with a concentration between 14 and 15 m (about 50 Roman feet). These data are particularly interesting because they demonstrate the trend in ancient building practice toward the use of standard measurements. In buildings that had multiple shells (21), the ratios between the outer and inner diameters were most frequently seen in the 2:1 and 3:2 ranges (fig. 2).

As previously indicated, centrally planned buildings were intended to express maximum elevation in the central room of the structure. The ratio between the central room's height and internal width needs to be recreated in order to calculate the building's interior volumes. Among the structures that preserve their original elevations (11), the following ratios between the inner width and the inner height (h_ratio) were identified:

– 1:1;
– 5:4;
– 1,6:1.

Most of these structures, as might be expected, were originally houses of worship or have undergone various reuses over the centuries that have enabled their preservation. The ratio of the thickness of the masonry and the internal elevation of the structures

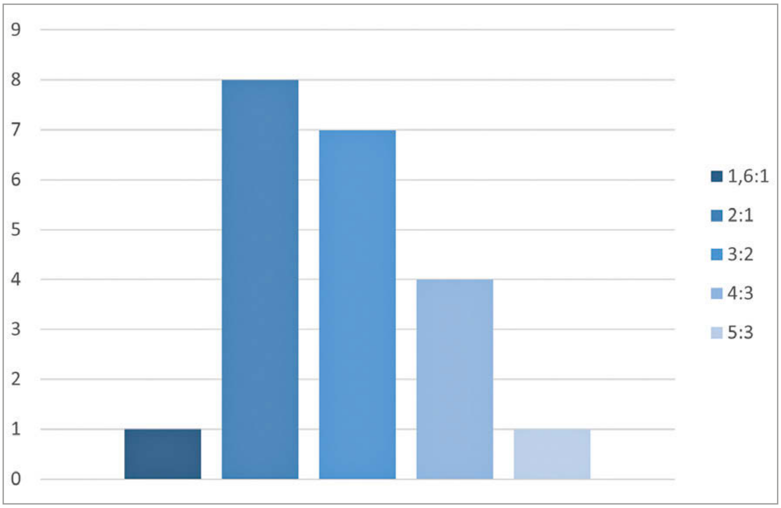

fig. 2. Plan proportion observed in buildings with multiple shells.

Buildings	Century	Sides	Function
Domus Aurea (IT)	1st CE	8	triclinium
laconicum – baths of Nerone (IT)	2nd CE	8	laconicum
roman villa of Aiano (IT)	4th CE	6	triclinium
villa of the Sette Sale (IT)	4th CE	6	triclinium
mausoleum of Diocletian (HR)	4th CE	8	mausoleum
palace of Galerius (GR)	4th CE	8	triclinium
mausoleum of Maxentius (IT)	4th CE	8	mausoleum
mausoleum of Galerius (GR)	4th CE	0	mausoleum
Tor De' Schiavi (IT)	4th CE	0	mausoleum
mausoleum of Helena (IT)	4th CE	0	mausoleum
mausoleum of Costantina (IT)	4th CE	0	mausoleum
temple of Minerva Medica (IT)	4th CE	10	triclinium
villa of the Vetti (IT)	4th CE	6	triclinium
baptistery of San Giovanni alle fonti (IT)	4th CE	8	baptistery
St. Aquilino (IT)	4th CE	8	church
Las Vegas de Pueblanueva (ES)	5th CE	8	funerary chapel
villa of Gran Via-Can Ferrerons (ES)	5th CE	8	triclinium
St. Paul (GR)	5th CE	8	church
martyrion of St. Philip (TR)	5th CE	8	church
hexagon of Antiochos (TR)	5th CE	6	triclinium
building of Gülhane (TR)	5th CE	6	triclinium
SS. Sergius and Baccus (TR)	6th CE	8	church
mausoleum of Maximian (IT)	4th CE	8	mausoleum
St. George (SY)	6th CE	8	church
St. Vitale (IT)	6th CE	8	church

tab. 2. List of centrally planned buildings.

(w_h_ratio) has also been provided as reference for the reconstruction of elevations. In reconstructing the layout of centrally planned buildings, a series of reconstructive hypotheses can be developed based on the case histories that emerged within the buildings under investigation.

In the future, further comparisons, particularly those related to the plan proportions of centrally planned buildings, can certainly improve the collected sample. Data on the building techniques used in the various structures mentioned would be another useful addition. The proportions governing the sizing of the various architectural components of the structure (height of the side rooms, height of the clerestory, height of the tax line of the central roof, etc.) could also be systematized for the buildings that maintain their original elevations. The development of datasets similar to the one just described will enable a full understanding of the choices made during the reconstructive process. In addition, it may serve as a helpful tool for those who will tackle the topic in the future by allowing them to draw inspiration from the reconstructive solutions used in other archaeological contexts.

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