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On the static and dynamic behavior of a prehistoric structure typical of Apulia in Italy

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Abstract

This paper examines the structural behavior to vertical and horizontal loads (static equivalent by horizontal forces) of a structure typical of Apulia, in Italy. The structure is in masonry and is called "*trullo*". It is very famous and is found only in Apulia. This structure, in fact, known as one of the "wonders of the world", was built in the prehistoric age and therefore it has not been realized by mean of a structural design, but only thanks to the experience of "master" builders.
By mean of a linear static analysis and having previously calculated the horizontal load, it has been possible to demonstrate the good resistance of this structure to earthquakes.
The results will give more information of the behavior of *Trulli* and if they need any retrofitting to dynamic loads.
Knowing the characteristics of this structure that make it resistant to the most severe actions, it will be possible to use them for future buildings. A structure of the past will become then a starting point for constructions of the future.
Finally, this research should give directions to the definition of sustainable methodologies that could be able to classify and control old structures and perhaps prevent their collapse, giving information on which interventions of consolidation are to be adopted.

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1. Introduction

A *Trullo* is a type of construction typical of the central and southern parts of Apulia region. A large part of the historical center of Alberobello town (near Bari) consists of *trulli*. Itria Valley, which stands these buildings, is protected by UNESCO since December 1996.

The early *trullo* was a kind of simple stone cottage with a nearly circular cross section. The *trulli* are built utilizing a simple technique, which ensures a minimum manufacturing of the material and, at the same time, avoids the installation of temporary structures necessary to sustain the vault during its construction [1].

A *trullo* is characterized by four principal elements: the wall, the trilithic entrance, the arch and the vault cap. All these elements are made of limestone with no binder type (Fig. 1; Fig. 2). Though their structures are very simple, they have been shown to have sufficient flexibility and durability to withstand several major earthquakes over the years. These dry-stone walls also have the advantage of having a low environmental impact and being economically efficient [2]. Dry masonry mechanics received little attention from research community, when compared with resources invested in traditional (mortar joint) masonry. Nevertheless, a large number of historical stone houses use dry masonry joints, while, in constructions originally built with weak lime mortar, mortar deterioration leads to a behavior similar to dry masonry [3].

From a resistance point of view, a *trullo* is composed of two major structural components: the basement and the vault.

The basement is made in a masonry sack consisting of two facing walls, spaced apart by a layer of disintegrated materials [4]; the thickness, of considerable size, has the function of restraining the horizontal loads, which are generated by the presence of the dome, although the latter has a structure that makes these loads minimal [5]. The basement, in addition, was not made orthogonal to the ground but the stones were arranged in such a way as to create a small inclination (about 10 °) relative to the vertical axis to give a higher stability to the wall structure.

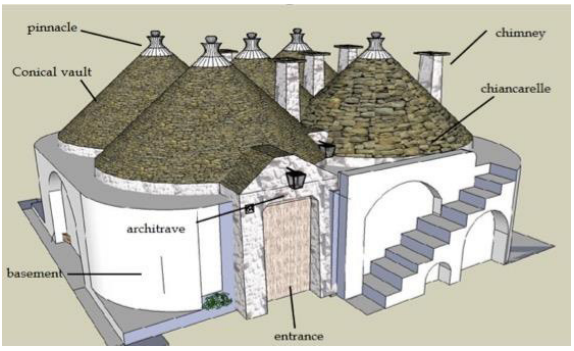

Fig. 1. Constructive elements of a *Trullo.*

After the basement, the vertical walls are built up to the design height; then, it proceeds to the construction of the vaults (the cones).

The vault of a *trullo* is realized with a method of construction, which provides for the implementation of a series of overlapped concentric rings of increasingly smaller diameter, up to a minimum opening, which is closed by a last stone. In this way and without any rib the vault of the *trullo* is realized, a simple stone structure that stands by gravity and by side contrasts, without the aid of any binder.

The cone is then covered with "*chiancarelle*" (slim layers of limestone), which are arranged with a slope towards the outside in order to facilitate the drainage of water.

The cover ends with the pinnacle, placed to complete the work, according to the fantasies of the "*trullaro*" builder.

The structural complexity of *trulli* means that they cannot be analyzed with the classical methods of investigation, and visual controls on-site are not sufficient. A preliminary safety assessment, in fact, requires a more detailed analysis that takes into account the geometry of the structure.