



Dipartimento di Architettura,
Disegno, Storia e Progetto
Università degli Studi di Firenze



Fondazione Romualdo Del Bianco®
Life Beyond Tourism®



Collegio degli Ingegneri
della Toscana



DOMES IN THE WORLD

Cultural Identity and Symbolism
Geometric and Formal Genesis
Construction, Identification, Conservation

Congress Proceedings
Florence, March 19-23, 2012

G. Tampone, R. Corazzi, E. Mandelli
Scientific Editors

NARDINI EDITORE



The International Congress "Domes in the World", held with the High Patronage of the President of the Italian Republic, is part of the "90 Days for Intercultural Dialogue" Programme conceived and promoted by Fondazione Romualdo Del Bianco® - Life Beyond Tourism® and included in UNESCO's International Year for Rapprochement of Cultures Programme

The views expressed herein are those of the individual authors and do not necessarily reflect the views of congress organisers.

The intellectual property and the responsibility of the English version of the papers reside with the authors.

ISBN 9788840442112

© 2012, Promo Florence Events – Fly Events srl

Scientific Editors: Gennaro Tampone, Roberto Corazzi, Emma Mandelli

Created by Promo Florence Events – Fly Events srl

Editorial Coordination: Michaela Zackova Rossi, Stefania Macrì, Antonello Usai

Printed by Multistudio Media srl, Florence

Cover Design: Lubos Hazucha

Nardini Editore

www.nardinieditore.it



Dipartimento Architettura Disegno Storia Progetto
Università degli Studi di Firenze
www.unifi.it



Fondazione Romualdo Del Bianco®
Life Beyond Tourism®
www.fondazione-delbianco.org



Collegio degli Ingegneri
della Toscana
www.collegioingegneri.toscana.it

DOMES IN THE WORLD

Symbolism and Cultural Identity, Geometric and Formal Genesis,
Construction, Identification, Conservation

Proceedings of the International Congress

DOMES IN THE WORLD

Florence, 19th – 23rd March, 2012

(the Congress is part of the “90 Days for Intercultural Dialogue” Programme, conceived and promoted by Fondazione Romualdo Del Bianco®-Life Beyond Tourism® and included in UNESCO’s International Year for Rapprochement of Cultures Programme)

Gennaro Tampone, Roberto Corazzi, Emma Mandelli

Scientific Editors

NARDINI EDITORE

BODIES PROMOTING AND ORGANIZING THE INTERNATIONAL CONGRESS “DOMES IN THE WORLD”

Fondazione Romualdo Del Bianco®-Life Beyond Tourism®

The Fondazione Romualdo Del Bianco®-Life Beyond Tourism® is a non-profit Florentine institution endorsing an array of cultural initiatives in order to encourage the intercultural dialogue, to enhance knowledge, mutual understanding and peaceful collaboration and to support cultural diversity in its tangible and intangible dimension, through an extensive network of over 450 universities, academies, libraries, museums, embassies, along with public and private cultural institutions and organizations from 60 countries in 5 continents.

Recently, after 20 years of activity, the Foundation elaborated a new concept of the cultural heritage as an instrument of understanding among cultures. According to this orientation, named Life Beyond Tourism®, cultural heritage is not only to be safeguarded and enhanced, but also to be “used and enjoyed” to foster intercultural dialogue; consequently, tourist is a “potential harbinger of knowledge and of intercultural dialogue” and therefore “the tourist destination is a workshop of knowledge, providing all visitors with an opportunity for cultural growth”.

Life Beyond Tourism® Non Profit Portal (www.lifebeyondtourism.org/new/) gathers the cultural expressions representing a given region to provide a good picture of its “cultural personality” resulting from the interaction between its cultural heritage and ongoing developments. The aim of the portal is to convey a territory’s specific features and to emphasize the way in which tangible and intangible heritage is combined to human and environmental levels. The portal is addressed to all cultural institutions, companies, professional and individuals who share the philosophy of the portal.

Università di Firenze, Dipartimento di Architettura - Disegno, Storia, Progetto

The Department of Architecture – Design History Project of the University of Florence develops its research activities according to the following six interest groups:

- Architecture and City section: studies the redefinition of techniques and teaching methods of projects on various levels;
- Architecture and Context section: primarily committed to morphological type research and related design experimentation;
- Architecture and Innovation section: mainly concerned with urban and architectural interiors, industrial archaeology and museology;
- Architectural Sites section: develops the analysis of the legacy of the masters, and the relationship with places of tradition, seeks to measure the deterioration suffered by the codes, rules and instruments of urban and architectural composition;
- Architecture and Design section: develops and tests research on scientific innovations in the field and in the representation of architecture and environment using the most up-to-date technological equipment;
- Architecture and City History section: develops research regarding Western architecture building elements of different periods.

Collegio degli Ingegneri della Toscana

The Tuscan College of Engineers (Collegio degli Ingegneri della Toscana), founded in 1876, is a non-profit cultural Association created for the purpose of disseminating technical-scientific knowledge in the field of engineering and architecture. These aims are achieved by means of conferences, visits, debates, seminars, courses and other pertinent activities. It publishes the “bollettino ingegneri”, a monthly magazine on engineering and architecture which was founded in 1953 and original scientific and technical articles, the reference price list for building activities and a guide of building categories and codes. The Association acts through the subsidiary company *Collegio degli Ingegneri della Toscana s.r.l. – società unipersonale*.

STEERING COMMITTEE

President

Gennaro Tampone University of Florence and the College of Engineers of Tuscany, (Italy)

Members

Paolo Del Bianco Fondazione Romualdo Del Bianco®-Life Beyond Tourism® (Italy)
Roberto Corazzi University of Florence (Italy)
Jerzy Jasienko University of Technology of Wroclaw (Poland)
Emma Mandelli University of Florence (Italy)

SCIENTIFIC COMMITTEE

Nuhad Abdallah (Syria), **Ali Abughanimeh** (Jordan), **Shukur Djuraevich Askarov** (Uzbekistan), **Ibrahim Ataç** (Turkey), **Abdel Aziz Salah Salem** (Morocco), **Carlo Blasi** (Italy), **Antonio Borri** (Italy), **Ugis Bratuskins** (Latvia), **Silvia Briccoli Bati** (Italy), **Giovannangelo Camporeale** (Italy), **Vito Cappellini** (Italy), **Stella Casiello** (Italy), **Mario Alberto Chiorino** (Italy), **Roberto Corazzi** (Italy), **Massimo Corradi** (Italy), **Giorgio Croci** (Italy), **Mario De Stefano** (Italy), **Angelo Di Tommaso** (Italy), † **Antonino Di Vita** (Italy), **Mario Docci** (Italy), **Nadezhda Eksareva** (Ukraine), **Natale Gucci** (Italy), **Francesco Gurrieri** (Italy), **Amra Hadzimuhamedovic** (Bosnia and Herzegovina), **Nana Iashvili** (Georgia), **Jerzy Jasienko** (Poland), **Andrzej Kadluczka** (Poland), **Alexander Kudryavtsev** (Russia), **Eva Kralova** (Slovakia), **Anna Lobovikov-Katz** (Israel), **Paulo Lourenco** (Portugal), **Giorgio Macchi** (Italy), **Varma Mahesh** (India), **Gulchohra Mammadova** (Azerbaijan), **Emma Mandelli** (Italy), **Claudio Menichelli** (Italy), **Claudio Modena** (Italy), **Abdurahman Mohamed** (Palestine), **Gabriele Morolli** (Italy), **Michele Paradiso** (Italy), **Amir Pasic** (Bosnia and Herzegovina), **Maurizio Piazza** (Italy), **Mohammed Reza Malek** (Iran), **Pere Roca** (Spain), **Paolo Rocchi** (Italy), **Guido Sarà** (Italy), **Maini Satprem** (India), **Ljiljana Sepic** (Croatia), **Maurizio Seracini** (USA), **Tetyana V. Sergeyeva** (Ukraine), **Paolo Spinelli** (Italy), **Gennaro Tampone** (Italy), **Farhad Teherani** (Iran), **Giacomo Tempesta** (Italy), **Ugo Tonietti** (Italy), **Athmane Touileb** (Algeria), **Grazia Tucci** (Italy), **Andrea Vignoli** (Italy)

ORGANIZING COMMITTEE

President

Paolo Del Bianco Fondazione Romualdo Del Bianco®-Life Beyond Tourism® (Italy)

Members

Roberto Corazzi University of Florence (Italy)
Marc Laenen Board Member for International Relations of the
Fondazione Romualdo Del Bianco®-Life Beyond Tourism® (Belgium)
Emma Mandelli University of Florence (Italy)
Gennaro Tampone University of Florence and the College of Engineers of Tuscany (Italy)
Antonello Usai College of Engineers of Tuscany (Italy)
Michaela Zackova Rossi Promo Florence Events (Italy)

ORGANIZING SECRETARIAT

Promo Florence Events
Via del Giglio 10, Florence (Italy)
Tel. +39 055 285588 domes@promoflorenceevents.org

PATRONAGES

The International Congress DOMES IN THE WORLD, organized with the High Patronage of the President of the Italian Republic, is part of the “90 Days for Intercultural Dialogue” Programme, conceived and promoted by Fondazione Romualdo Del Bianco®-Life Beyond Tourism® and included in UNESCO’s International Year for Rapprochement of Cultures Programme.



The Iblei's stone landscape: the *muragghi* through geometry, structure, shape and nature

Franca Restuccia¹, Corrado Fianchino², Mariateresa Galizia³, Cettina Santagati⁴

Abstract Among the rural artefacts of the Iblean plateau there are still today constructions belonging to vernacular tradition. They are made of dried and assembled with megalithic method and represent the history and the rural culture of Southern East Sicily. The *muragghio* has got a truncated cone shape. The construction is enveloped by helicoidal ramps which reach the top of the viewpoint from which it is possible to admire landscape. The interior is covered by a dome built in stone without mortar, showing great constructive skills. This is a dome hidden from the outside and it rises by concentric circles of overlapping stones. The aim of this interdisciplinarity study carried out by Drawing and Architectural Technique researchers, through survey, geometric analysis and the study of constructive techniques, is to investigate the relation which exists in the *muragghi* through geometry/construction/shape and the nature of the places, in the Iblei's stone landscape.

Keywords laser scanning, geometry, building techniques

1. INTRODUCTION

The long and hard work of clearance of stones of the fields for the cultivation of the lands by the local populations, which increased, above all, in the first half of the nineteenth century following the abolition of feudalism which made the land free, has modified and characterised the territory of Ragusa over the centuries.

Over time the lands destined for agriculture have been shaped as well as marked through local limestone which, thanks to its clear and ductile characteristics, draws a system of lines (dry stone walls) and landmarks (huts, fods) on the land which represent deep material and social connections in the territory. Stone, therefore, plays the role of raw material as well as that of an instrument and a sign of the *contadino's* work who uses it as a defence from dangers and the elements as well as a means for the economy of the territory.

It is a stone landscape consisting of a thick geometric mesh made up of matter and man's work, the result of a huge work and of a culture of stone which has developed in the various Mediterranean territories according to the peculiarities of the natural and socio-economic resources as well as to the various historical events. A wealth of artefacts of stone ashlar, stacked with no binding mortar, which has developed formal and building expressions closely linked to the territory, in which the use of stone affects the whole context of the agricultural system: from the functional element of the containment

¹ Franca Restuccia, Department of Architecture, University of Catania, Italy, franca.restuccia@alice.it

² Corrado Fianchino, Department of Architecture, University of Catania, Italy, cfianchi@dau.unict.it

³ Mariateresa Galizia, Department of Architecture, University of Catania, Italy, mgalizia@dau.unict.it

⁴ Cettina Santagati, Department of Architecture, University of Catania, Italy, cettina.santagati@dau.unict.it

wall, which levels and increases cultivatable land, to the construction of infrastructures (stairs, paths, boundary walls) and of small buildings.

The small constructions and the dry stone artefacts which were part of the cultivated lands, and which still dot the Hyblaean landscape, are the sign of a way of life as well as of human work which embody the material culture of the territory. These elements contain de facto all evident aspects of local culture, and for this reason they are themselves the memory not only of the architecture of the time but also of a past reality, of the ideas of the people and of the conditions of the territory, of the connection with the craft and the territory, of the procedures and techniques used to create, to use or to destroy the artefacts themselves. Thus, they have the value of material role as they are the result of traditional techniques of production and transformation of nature, at the same time representing the sedimentation of past experiences, as they were determined by the different economic, social, and cultural needs.

This work is the result of an interdisciplinary collaboration between Drawing and Technical Architecture researchers; it aims at the scientific documentation of typical “architecture without architects”, that is, the *muragghi* – which are watchtowers distinctive of the Hyblaean farms, in the shape of a truncated cone – in order to understand their deepest meanings. Through the techniques/aid of Survey and of Representation the Ragusan *muragghio* of Villa Trippatore has been carefully studied in order to understand the geometry and the building methods as well as the technique and the arrangement of the elements connected to it, and to infer the historical and anthropological meaning these constructions have assumed over time.



Figure 1 – Territorial identification of the *muragghio* of Villa Trippatore in Sampieri, Ragusa

An instrument survey through 3D laser scanner was carried out, in order to obtain some synthesis images which convey the infinite amount of data essential to document the architectural element in all its form and material nature: from structure to morphology, from geometry to methods, from details to the material used. In this way a survey has been obtained which is, at the same time, a faithful representation of the actual situation and which represents an effective aid to the understanding of the relationship between geometry/structure/form and the nature of the territory. The use of technical solutions has been investigated in depth in order to understand “the use of materials and their becoming a building system” (Giandebiaggi: 2006), within the uniform stone landscape of the Hyblaean Mountains.

This example case is part of a wider research work carried out by the interdisciplinary team, which compares similar architecture in order to understand, mark and describe all possible homogeneous as well as diverse aspects essential to a conservative and restoring action on the artefact on the one hand, and to include such cultural and landscape heritage within the context of the enhancement of the Sicilian territory on the other.

These spontaneous constructions represent the Meditarrenean nature: they are artefacts shaped by the place itself and by the relationship established with the place chosen according to the various needs,

which affect the choice of the forms and of the building materials. Today, such constructions, a synthesis of brilliant pragmatism and vital needs, are mostly in a serious state of disrepair, because of changes in the use of the land and in the socio-economic development.



Figure 2 -3 – (on the left) The double-flight-of-stairs system of the *muragghio* of Villa Trippatore in Sampieri, Ragusa; (on the right) the *muragghio* and the system of terraces, cisterns, garden in which it lies.

This leads us to suggest an action for the recovery of these assets which contain a series of values ranging from visual-formal values, to craftsmanship, recreational, cultural values, and, thus, are an authentic heritage to be safeguarded and enhanced not only as a source of immaterial well-being but also as an economic resource to be used, for example, for the development of cultural and rural tourism, in keeping with the principles of sustainable development, and, finally, as a form of defence of the territory and of the environment.

2. THE MATERIAL CULTURE OF THE TERRITORY

The geological conformation of the territory of the Hyblaean plateau is characterised by the presence of calcarenite formations with alternations of fine grain grey limestone, soft marly limestone, white yellowish calcarenite more or less soft and more or less cemented alternating with greyish marly calcarenite, laminated and stratified calcarenite and calcirudite. The calcarenites are sometimes more or less impregnated with bitumen. Other times, within the territories of Buccheri and Vizzini there are also vast areas of basalt such as the remains of lava flows. The presence of so many varieties of calcarenite formations has created, over time, an authentic Natural Stone Culture and a material culture mainly based on the extraction, production and manufacturing of stone material. Throughout the Hyblaean territory, basically the south-east of Sicily, various ornamental and building stones are used. The main ornamental stone is the Soft Limestone, or Siracusa Stone, or Noto Stone, which is easily workable and which gave rise to the eighteenth-century late baroque architecture as well as determining the colour of the cities rebuilt in the eighteenth century, that is, Modica, Ragusa, and Noto which, today, are all UNESCO World Heritage sites. The soft limestone, in the area of Ragusa, is sometimes impregnated with bitumen, and appears so dark that it is called Pitch Stone. Another stone material widely used as both ornamental stone and building stone is the so called “Comiso Stone”, which is quarried in the area of Comiso from the quarry walls with various layers of calcisiltite of a whitish colour and of a different thickness.

Another stone material is that which comes in the form of white-yellowish stratified calcarenite protruding in thin (30-50 cm) layers, which is easily identifiable in the uncontaminated context of countryside of the Hyblaean plateau. Stratified thin plates of calcarenite can be seen which, appropriately cut, result in the so called “Modica Stone” (Fianchino: 1988).

Such widely spread protruding plates provided that stone, slightly hewed, to be used directly on the spot, as erratic rocks, in order to build that thick network of dry stone walls which characterises the Hyblaean plateau. The function of the tiny dry stone walls was either to delimit the areas of land or for changes in ownership or to diversify the cultivations. The passing of time and the changes in

ownership or in cultivation caused the destruction of these walls. The scattering of the stone over the lands together with the ashlars resulting from the spontaneous or natural breaking of the plates made agricultural work difficult and required special work of stone clearance of the fields in which such scattered stone accumulate in large heaps.



Figure 4 – Working of the Modica stone plates

The abundance of such basic material stimulated the creativity of the craftsmen who organised the stone in authentic “spontaneous” constructions according to empirical working methods typical of the territories rich in stone material. Such constructions concerned “capanni [huts], carccare [kilns], manniri [fods], cuccummeddi [circular dry stone walls used to protect trees], muragghi”. The forms are ogival, circular, spiral, terraced, and are already classified (Tiralongo: 2006).



Figure 5 – *Capanni, carccare, manniri and cuccummeddi*

Among these spontaneous constructions the most interesting ones are the so called *muragghi*, which reproduce circular forms and create authentic interior spaces with overhanging dome roof.



Figure 6 – Muragghi in the Hyblaeen territory

Thus, a laser scanner survey of one of the most interesting *muragghi* existing in the territorial context concerning this research, that is, the *muragghio* lying near “Villa Trippatore”, was carried out. According to the information provided by the owner Baroness Gravina, it was built during the first decades of the twentieth century on the occasion of extension work at the villa and the reorganisation of its external spaces. The *muragghio* appears as a massive construction, still in good condition, lying on a high terrace in order to have good viewing characteristics from the belvedere terrace on the levelled roof. The characteristics of a geometric nature and of inclusion in the territorial context will be examined in the following paragraphs of this paper.

3. IL MURAGGHIO DI VILLA TRIPPATORE A SAMPIERI: ARCHITETTURA IN PIETRA A SECCO

The containment walls of the land or those dividing the various estates, the *capanni*, the *macere* (heaps of stones), the *muragghi*, are artefacts which draw simple stone geometries on the territory, and which enrich the Sicilian countryside with history and ancient knowledge.

This spontaneous architecture is characteristic of south-east Sicily as well as other parts of the Mediterranean region – Puglia, Abruzzo, Sardinia, Spain, France – and they exist thanks to the abundance of suitable stone material and the need to clear the land of stones in order to cultivate it besides the natural demand for the construction of structures for the defence of the territory and for the accommodation of machines, animals, and people.

The origins of the culture of the working of stone for construction as an aid to agriculture are very old, a practice which was refined over time so as to reach special geometrical/formal and technological/building solutions in the Ragusan *muragghi* which find their archetypal models in the cabin, in the *tholos*, or in the natural cave.

Rural stone constructions, the *muragghi*, are signs of old agricultural traditions of the Ragusan territory in which the warm colour of limestone merges with the blue of the sea and the green of the cultivated lands. They represent a typology of artefacts which uses dry stone building methods, which are common to prehistoric or protohistoric buildings of major historical and architectural importance (Mycenaean and Greek funeral *tholoi*), and which are based on the use of stone as the only building material, with no use of mortar.

Similar to other Mediterranean constructions – the nuraghes in Sardinia, the trulli and the *pajari* in Puglia, the *cubburri* in the Nebrodi Mountains – the *muragghio*, dialect for walls, is a distinctive watchtower of the farm, in the shape of a truncated cone, which lies directly on the ground, or on terraces lying on a higher level which make the building stand out even more in the rural landscape.

The often monumental dimensions this tiny architecture assumes are visually conveyed by the flat surfaces, mostly quadrilateral-based 'podiums', and by the terraces of circular concentric planes with decreasing diameters, which, like in the ziggurat, raise the structure towards the sky.

The *muragghio* is characterised by hard local limestone ramps, mostly helix-shaped, carved into the mighty wall thickness of the construction, which reach the top of the belvedere from where it is possible to control/admire the surrounding landscape.

Besides, one of the characteristics these rural constructions have in common is the inner space covered with an overhanging dome consisting, with great practical/building expertise, of concentric lines of stones stacked with no mortar to support one another during construction without using any centring.

The *muragghio* of Villa Trippatore in Sampieri, which once was a fishing village and now is a hamlet on the Scicli coast in the territory of Ragusa, rises in the *contrada* with the same name. The rural construction stands inside the estate as part of the villa which was originally the summer residence of the Barons Penna, now Barons Gravina.

The villa, aristocratic architecture dating back to the second half of the nineteenth century, was built on ancient structures belonging to the church and privatised following the state laws of expropriation of church property. Immersed inside the vast estate, the mansion was enriched with constructions to support agriculture in the twentieth century: a wide cistern and a *muragghio* to watch the farm, by using Modica stone obtained from the stone clearance carried out for the creation of the large area at the back of the villa.

The *muragghio-belvedere*, imposing and elegant in its forms, is immersed among the palms of the Italian style garden which lies at its foot, in a single composition system together with the semi-underground cistern.

Unlike the other examples in the Ragusan territory, the Trippatore *muragghio* represents the key element of a carefully planned and large-scale design solution. It rises at a terrain level higher than the villa, thus dominating the view of the coast southwards and controlling the estate from the other sides.

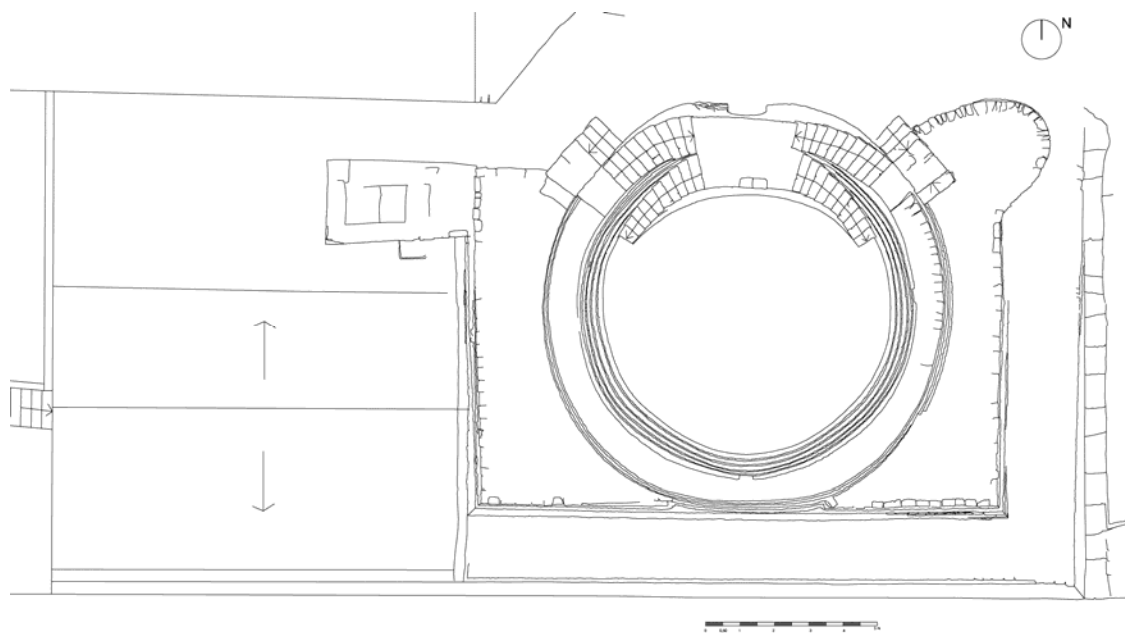


Figure 7 – Plan of the roof and identification in the context

From the northern courtyard of the house, through a flight of hard Modica stone stairs, it is possible to access the roof of the cistern, paved with large plates of the same stone, which becomes a walkable terrace with a slight double slope for the collection of rainwater for irrigation.

The cistern, which is also made from Modica stone, has two entirely underground sides and two exposed façades, one onto the courtyard and the other onto the garden, which are made from limestone ashlars. Slightly raised above the roof of the cistern there is a well from which water for irrigation is drawn.

On the eastern limit of the cistern, the terrace, on which the truncated cone-shaped construction of the *muragghio* lies, is set. Of a truncated pyramid shape with two steps of a total height of 0,70-0,80 m, it

consists of containment walls built in stacked lines of squared limestone ashlar of a homogeneous size, except for the edges which consist of large stone blocks which function as corners. Another terrace, lying on a lower level, surrounds the construction only from two sides (east and south), and a stone ramp runs along the eastern side reaching the garden below with a slight slope.

Inscribed in the rectangle which forms the base of the terrace, at a higher level and lying on it, a truncated cone-shaped 'podium', which has a circular base with a radius of about 6 metres and consists of six/seven lines of stacked ashlar on which the whole construction rests, rises as a tangent to the southern side.

The *muraghio*, made entirely from large blocks of roughly squared local calcarenite, rises for a total height of about 5 metres on slightly indenting (about 5 cm) large steps, that is, to be precise, five concentric truncated cone-shaped surfaces.

The development of the construction according to successive rings of smaller diameter and of variable height (lines at the bottom no. 7, in the middle no. 4, at the top no. 5) gives this simple architecture a greater verticality; besides, the solid and compact wall mass is interrupted by the chiaroscuro of the shadows which form on the exposed edges of the terraces.

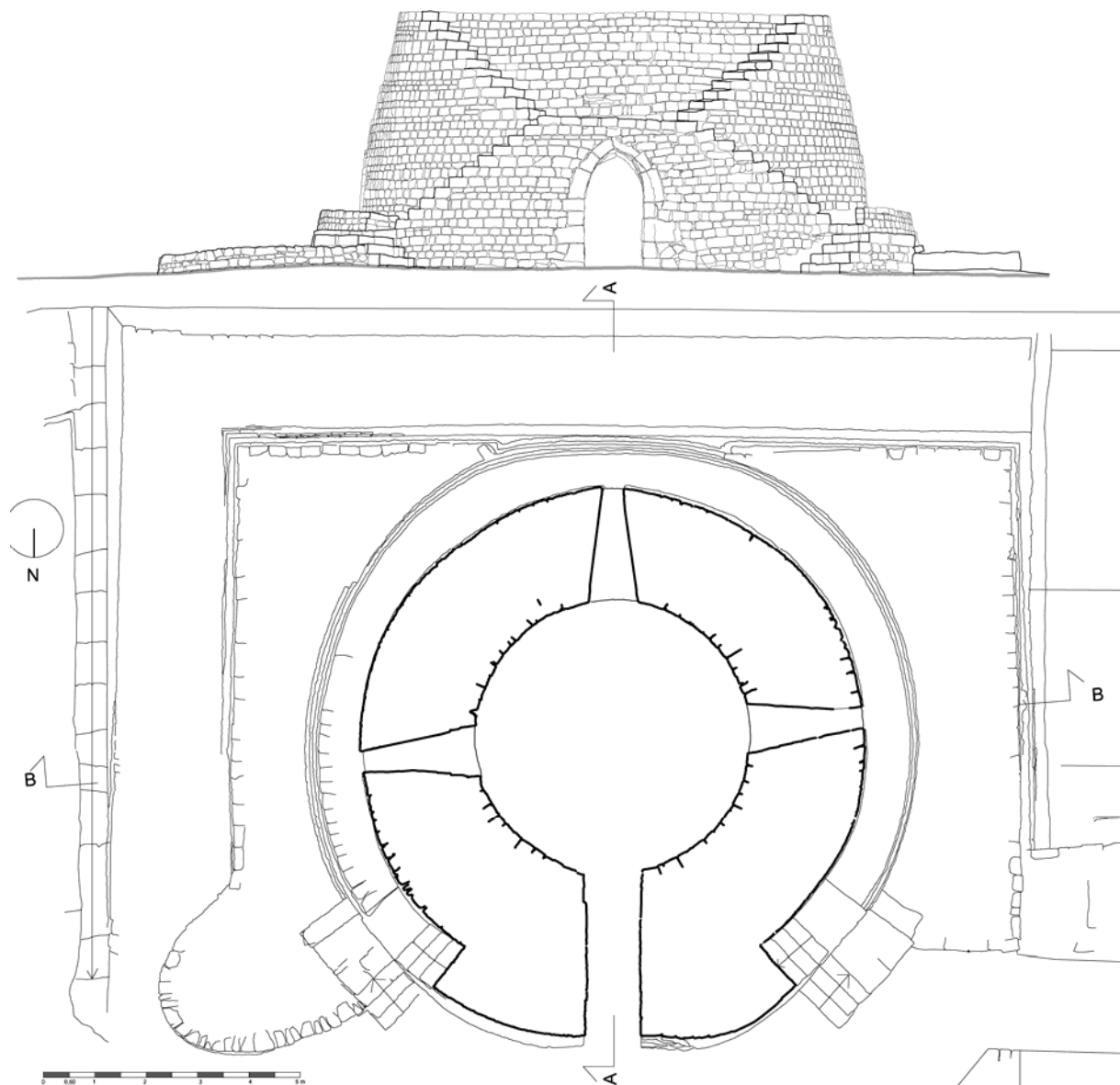


Figure 8 –9 – Northern façade and plan of the *muraghio*

The whole wall mass is made lighter by four openings facing the cardinal points – the ogival entrance and the three rectangular windows with rectilinear architraves – which illuminate the interior. The

frames of the openings consist of stone ashlar which are uneven and larger than those of the lines, and form a frame around the opening.

Two helicoidal two-flight stairs, lying symmetrically at the entrance and with no parapet, stand on the surface of the *muragghio* and are partly carved into the wall thickness. Such an arrangement entails a constant width in the first flight (about 0,95 m), since it is external to the perimeter wall, unlike the second ramp which presents, as the level increases, a section which becomes narrower near the top (about 0,60 m). The steps appear slanted towards the inside, and maintain their perpendicularity with the truncated cone-shaped surface on which they stand, as if to defeat the eventual centrifugal force generated by the building's geometry.

At the top the flat roof, with a slight slope towards the outside, is covered with shapeless limestone of small size and edged along the circular perimeter by the upper side of the ashlar of the last line.

The entrance with an ogival arch facing north, in Modica stone ashlar arranged radially, stands on frames consisting of large stones of various size; it leads to a passage area, a narrow corridor covered with a barrel vault with ogival directrix, and rectilinear and horizontal generatrices.

The inner room with a circular plan, illuminated by the four openings, is covered with a dome standing on the main walls. Hidden inside, this dome rises on 27 concentric lines of stone ashlar gradually projecting towards the centre, ending at the top of the room. It is, thus, a self-supporting structure, a overhanging dome, which rises according to successive horizontal rings of decreasing diameter, distributed on a mainly horizontal floor. A building arrangement similar to the *tholos*-shaped roofs of Mycenaean or Etruscan tombs, in which stone elements are self-supporting, thus avoiding the use of centring.

From the very first inspections carried out it was assumed that the dome consists, at the top, of a conical surface with rectilinear generatrices, standing on about one quarter circumference which concerns the first 14 lines. The outline of the vertical sides of the ashlar of the impost of the dome determines the geometry of the vault in order to obtain an even and non-jagged surface.

In the last part of the dome, the profile becomes curvilinear again with ashlar having a slanted or horizontal position according to the level to be reached for the end cap.

A fast and economic, yet forceful, building method. An aid to the stability of the construction, the thick wall mass, arranged into large steps, acts as a counterweight.

The vertical end is a double-face "a sacco" wall, about 1,20 metres thick in total, consisting of two battlements in solid limestone ashlar roughly squared in staggered joints; two battlements in the middle of which, through the fissures, the filling consisting of small, shapeless stones can be seen.

The whole construction represents, for its geometrical-formal and technical-building features, an example of local material culture which still today characterises the Ragusan territory, and offers evocative images which portray the union of nature and inhabited space, stone and man.

4. A DIGITAL SURVEY FOR THE KNOWLEDGE OF THE TRIPPATORE *MURAGGHIO*

4.1. Problems concerning the survey and the representation of dry stone artefacts through a 3D laser scanner

The research carried out on the Trippatore *muragghio* aims to obtain a complete documentation of the artefact from the point of view of both its form and construction in order to be able to study its geometry by concentrating, as a first hypothesis, on the analysis of the overhanging dome which covers the inner room.

Indeed, only through a detailed geometrical analysis, despite the irregularities of the stone ashlar, has it been possible to give answers to the questions and hypotheses formulated from the very first inspections in order to understand the building method with which the *muragghio* was built in relation to the examples already known in the literature.

Despite being aware of analysing a rural artefact made in ashlar of irregular size by craftsmen highly skilled in dry stone walls, the dimensional and material characteristics of the *muragghio* have led us to use the 3D laser scanner technology so as to acquire as much information as possible and to make all the tests necessary for the geometrical analysis in an accurate manner.

The obtained digital model – a cloud of points – documents exhaustively both the form and the material of the artefact, thus revealing its three-dimensional complexity in the virtual space of the computer.

The 3D HDS 3000 laser scanner belonging to the “Luigi Andreozzi” Laboratory of Architectural Photogrammetry and Survey of the Department of Architecture of the University of Catania.

The phase of on-site survey took into consideration the morphological-dimensional characteristics of the *muragghio*, and was influenced by the presence of trees and vegetation near the artefact which forced us to increase the number of scans in order to obtain a total coverage of the object. Three-dimensional targets, where possible, were used, since they allow us greater precision, and are time-saving during the following phases of editing and recording of the various scanings into a single model (Santagati: 2009; Santagati: 2011). Attention was paid, in any case, to make scans with a good overlap margin so as to be able to proceed, during the recording phase, also through collimation of homologous points.

From an operational point of view the survey of the truncated cone shape of the building made the verification of data necessary in the areas in which the laser affects tangency because of the loss of data in the model which could cause subsequent overlap problems between one scan and the next.

The project of data acquisition, thus, consisted of one inside scan and 8 outside land scans, one of which was made from the mid-landing of the double flight of stairs which leads to the top-belvedere which is about 3 metres from the ground. The selected step-scan (10 mm) optimises on-site timing with the needs of the research so as to obtain a detailed description of both geometrical and building characteristics (i.e., the texture of the ashlars).



Figure 10-11 – (on the left) Phase of the on-site survey, (on the right) views of the cloud of points

The union of the single scanings in a single model system took place through the use of three-dimensional targets (semi-automated procedure) and homologous points with alignment error equivalent to 3 mm. The metrical quality of the obtained model was tested within the proprietary software during subsequent phases: creation of a layer for each scanning, selection of various colours, carrying out of slices on the model with slices 1 cm thick according to horizontal and vertical planes; accurate comparison of results. The test carried out provided more than positive results, with an accuracy contained within the instrumental error.

From the overall model thus obtained, about 33 million points, were then removed the disturbing elements such as plants and vegetation so as to facilitate the following phases of graphic rendering and geometrical analysis.

The need to document a truncated cone-shaped artefact according to traditional graphic methods (plans, perspectives, sections) which highlighted also the material consistency of the wall texture made it necessary to pay great attention to the choice of model systems to use for the relevant graphic rendering of the perspectives and of the sections.

The first objective was to identify the virtual centre of the inner circumference of the base for the insertion of planes of radial sections joined to the axes of the openings. Subsequent approximations were made by slicing the cloud of points at different levels with profiles of horizontal sections, by drawing, through points, the relevant theoretical circumferences, and by interpolating the average of the centres so as to identify the theoretical centre.

Then, two sections, one longitudinal and the other transversal, passing through the theoretical centre of the circumference at the base and the axes of the openings, were set; the non orthogonality between the axes made the definition of two different model systems (UCS) necessary.

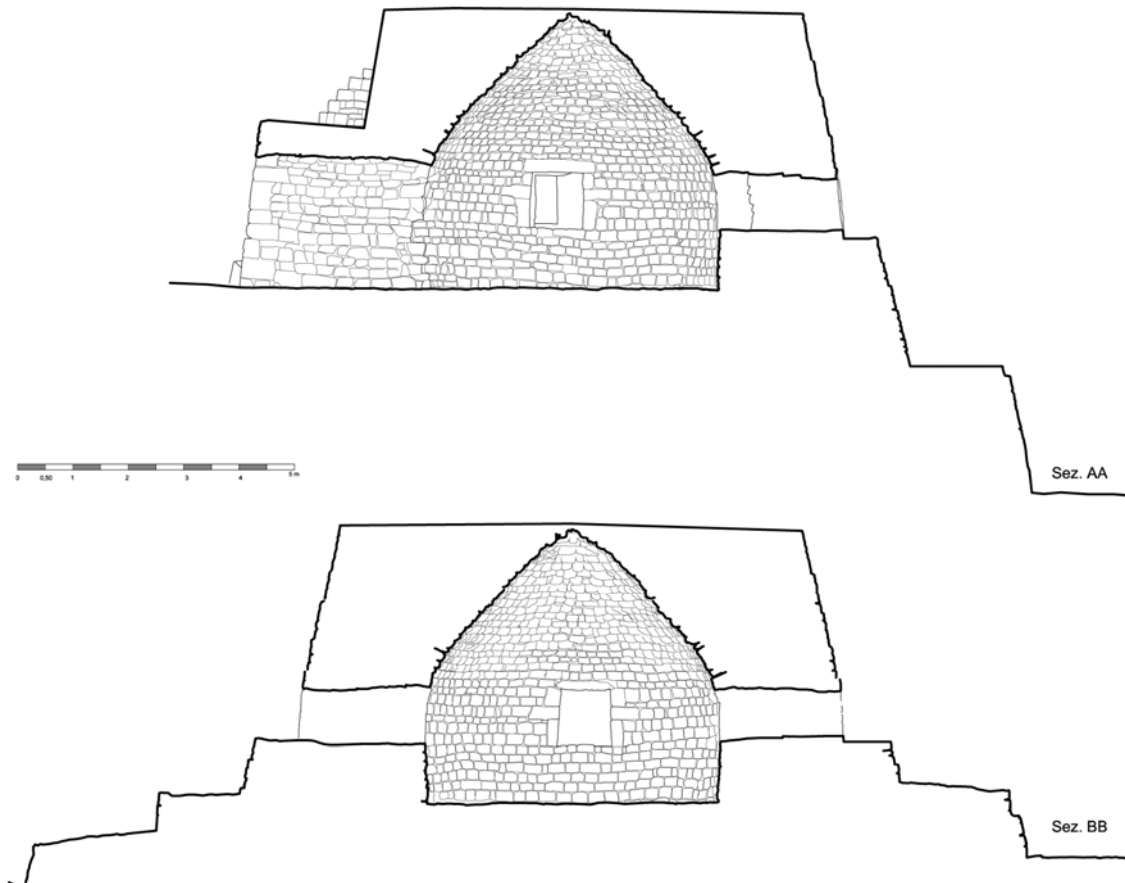


Figure 11-12 – Longitudinal and transversal sections of the Trippatore *muragghio*

As for the elevations, the model planes on which to make the projection were chosen according to the two model systems previously used so that, despite the projection of a curved surface, the openings and the relevant frames and architraves were represented in their actual form and size.

4.2. Geometrical analysis of the overhanging dome

The geometrical analysis of the overhanging dome which covers the inner room required the creation of other graphic works to better understand the object being studied. For this reason, besides the sections previously created, 4 other radial profiles-sections, necessary to verify the formulated hypotheses on the course of the inner curvature and on the methods for the installation of the ashlar, were extrapolated.

Moreover, we created a hyposcopic map, which made it possible to observe, in a clear manner, the course of the exposed surface of the ashlar whose dimensions increase gradually from the impost block at the top, as well as a plan view of the dome through level curves with profiles extrapolated with a 30 cm step-scan which made it possible to verify – when the laser managed to penetrate between one ashlar and the next – the parallelepiped shape of the ashlar.

This latter instrument proved to be of great importance since it confirmed the change, which was noticed from the very first inspections, of the course of the horizontal section of the dome which,

gradually moving towards the top, from a circular form, assumes a more flattened shape which can be recognised as an ellipse with a smaller axis corresponding with the entrance to the artefact.

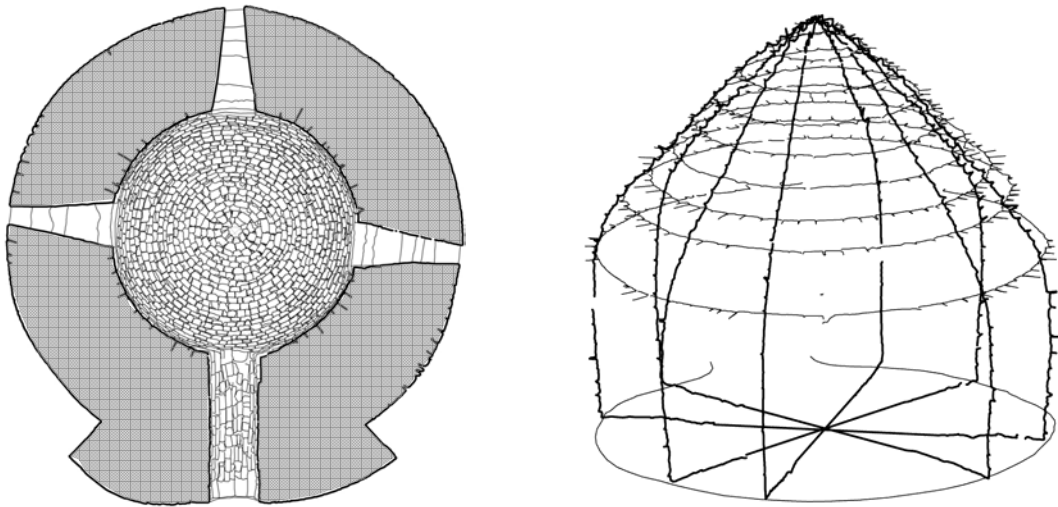


Figure 13-14 – (on the left) hyposcopic plan with texture of the ashlar; (on the right) 3d view of the horizontal and radial profiles.

The analysis of the radial profiles created through planes passing from the centre of the ideal circumference of the base revealed various elements which supported the verification of a few formulated hypotheses, and, at the same time, raised fresh issues to be solved by seeking feedback from both traditional building techniques and historical models.

The impost block of the dome lies at the same level as the threshold of the openings, at about 1.28 metres from the ground; the curvature of the generating profile is not just one piece but consists of a portion of the circular profile which goes from the impost up to about 3.40 metres from the ground including 14 lines (with an underlying angle of about 50°) on which an almost tangent rectilinear profile stands, which then again becomes curvilinear in correspondence with the last 4 lines of the end of the dome (at about 4.40 metres from the ground).

To sum up, after disregarding all inevitable geometrical irregularities due to imperfections of installation, to the size of the ashlar, and to possible structural failures, it can be said that the inside of the *muraghio* is a room with a cylindrical base on which a portion of a hemispherical dome (about one quarter), surmounted by a truncated cone with nearly rectilinear generatrices, stands.

As has already been said, since dry stone walling is involved, when the laser managed to penetrate between one joint and the next, it was possible to verify the dimensions of the installed ashlar. At the lower end of the dome, in correspondence with the first part consisting of the hemispherical portion, it has been noticed that, in some parts (above all, in correspondence with the openings), the ashlar, of a parallelepipedal shape, are arranged according to inclined beds (maximum inclination of about 27-30 degrees).

The passage from the circular curving to the rectilinear curving, which is necessary to increase the total height of the *muraghio*, in certain points takes place as a tangent, in the other points it is possible to observe some discontinuities. As a first hypothesis it can be assumed that the decision to change the profile was made during the work: presumably the craftsmen realised that by continuing the installation with slanted ashlar the height of the *muraghio* would be too low to control the territory. For this reason, the vault was raised with the consequent modification of the curving, from circular to rectilinear, thus obtaining a higher turret.

The conformation of the faces of the ashlar of the truncated cone-shaped part of the *muraghio* reveals the construction of the overhanging dome. In practice, the height of the ashlar remains almost constant for the whole elevation of the dome (about 12-15 cm), the curving being obtained by shaping the exposed face of the ashlar according to a constant inclination of about 47° with a projection of the ashlar of about 10 cm.

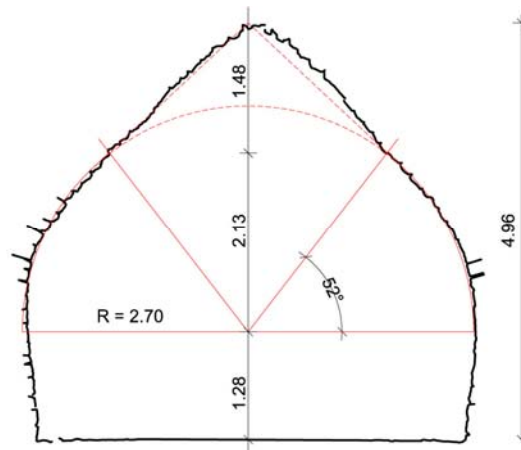


Figure 15 – Geometrical analysis of the inner room of the *muragghio*

Finally, the last part of the profile, that which ends the dome, presents a rectilinear course curving with the ashlar arranged in either a horizontal or an inclined line according to the level to be reached for the end cap.

5. BUILDING FEATURES

The sections of the drawing of the inner surface of the intrados of the dome roof highlight some characteristics of the joints among the ashlars which, criss-crossed with the direct survey of the same ashlars, seen from the inside, suggest the use of the “overhanging ashlar method”, also known as “False vault”, but applied with a mixed technique. The overhanging ashlar method creates the curve form with a simple superimposition of parallelepiped ashlar with horizontal overhanging lines and setting bed/lines with no overturning occurring. Stability is ensured through counterbalancing of the above wall mass. As it clearly appears, it does not require the use of centring for its construction. The unique characteristic of the method is represented by the horizontal setting bed/line of the various ashlar, which, in this way, appear as parallelepipeds with the upper face and the lower face parallel and horizontal, and the exposed face slanted. The sections of the drawing, however, reveal that the blocks of the first lines are not horizontal but inclined. It has also been observed, from the direct survey, that all of the ashlar, also those of the first lines, have parallel upper and lower faces, and inclination is obtained by the use of stone chippings which raise the ashlar at the back thus giving it a certain inclination. They are always positioned with the exposed face inclined and overhanging from the lower ashlar. It is difficult to be precise about the angle of inclination of these lines since the irregularity of the ashlar and of the installation does not ensure the accuracy of the survey, although the survey with a 3D laser scanner has revealed a maximum inclination of 27-30 degrees. In this case, it is assumed that an inclination was used which ensured stability, during the construction, thanks to the friction between the stones, which are mostly below 30 degrees. This is the mixed technique between ashlar arranged in horizontal ranks in the upper lines and ashlar arranged in an inclined rank in the lower lines. A mixed technique belonging to the history of construction which has built up over time. It has remained as empirical practice in the technical actions of the spontaneous building culture of the craftsmen: the so called *murassiccari*. It has also been observed in the dome of Hagia Sofia in Constantinople in an essay by R. Gulli and G. Mochi (Gulli R., Mochi G.: 1997) who mention other historical monuments built with inclined ashlar such as the famous warehouses of the Ramesseum and the vault of Chosroes I's palace in Ctesiphon. In the essay they write: *“I pennacchi,..., sono realizzati con una tecnica intermedia tra quella a falsa volta, caratterizzata dall'impiego di conci successivamente aggettanti e posati su letti di posa piani privi di legante, e il sistema costruttivo che prevede l'utilizzo di filari di laterizi inclinati e posti in opera senza l'ausilio di alcuna centina, usufruendo pertanto della capacità adesiva offerta da una malta grassa. L'apparecchio costruttivo prevede la messa in opera di laterizi secondo letti conici di malta aventi come vertice non il centro della sfera che costituisce l'involuppo delle serie di quattro pennacchi, bensì un punto situato a quota più alta in modo che l'inclinazione dei laterizi risulti sempre inferiore al limite di scorrimento relativo tra malta e laterizio. Con maggiore profitto questo apparecchio viene impiegato dai costruttori anche nell'erezione della cupola; infatti l'autoportanza*

connessa all'utilizzo di una malta grassa rende più semplice la realizzazione della copertura eliminando la necessità di sostenere i laterizi sino alla chiusura dell'anello.”⁵ This method of mortar conical beds was well-known at an operational level also by craftsmen who used it for the construction of small false vault domes with firebricks. They would raise the brick at the extrados with plaster conical beds, in this way managing to end the ring and to reduce the number of lines (Fianchino: 1983). The use of mixed techniques for the domes with the overhanging ashlar system is fairly common in the Hyblaean region, and they have already been observed in the building systems of the Byzantine domes still existing in the south-east of Sicily. This technique has been observed in the example of the dome of the *Trigona* of Cittadella near Vendicari, for the construction of which the use of the overhanging ashlar technique for the first five lines on the one hand and the use of a juxtaposing ashlar method for the last four lines on the other has been hypothesised (Margani: 2005).

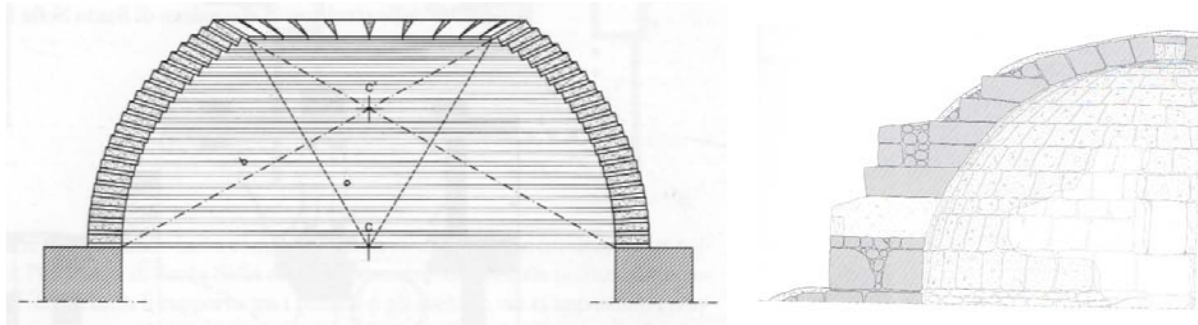


Figure 17-18 – (on the left) building method of a dome with bricks arranged on horizontal beds and inclined conical beds; (on the right) building section of a dome with horizontal beds and radial beds

This method is also hypothesised in the case of the circular plan construction with domed roof, called the “Favorita” in *contrada* Frammedica in which the remains of the monument highlight the survival of the first lines (today three, perhaps 5 in the drawing by Houel) of ashlar with a horizontal setting bed whereas for the lines of the roof the use of a juxtaposing ashlar technique is hypothesised (Trapani: 2008).



Figure 19-20 – (on the left) the “Favorita” in a 2008 recent photo and (on the right) in a guache by Jean Houel

The presence of intermediate and mixed techniques in the same structure, even within the same method of overhanging ashlar, demonstrates great building wealth, and, thus, a phase of the evolution towards a major definition of the building methods of the ashlar vaults in the south-east area of Sicily in which the material culture is characterised by the use of natural stone.

⁵ “The pendentives, ..., are built according to a technique halfway between the false vault technique, characterised by the use of successively overhanging ashlar standing on flat setting beds with no binder, and the building system based on the use of lines of inclined bricks positioned with no centring, thus exploiting the adhesive capacity offered by fat mortar. The building system entails the installation of bricks according to mortar conical beds having as their vertex not the centre of the sphere which is the union of the series of four pendentives, but a point lying at a higher level so that the inclination of the bricks is always lower than the creep limit between the mortar and the brick. This method is used, with greater benefit, by the builders also in the construction of the dome; the self-supporting quality connected to the use of fat mortar makes the construction of the roof easier by eliminating the need to support the bricks up to the end of the ring.”

ACKNOWLEDGMENTS

The authors wish to thank the Baroness Fanny Gravina for granting access to Villa Trippatore and the engineer Umberto Grimaldi, technician of the section of the “Luigi Andreozzi” laboratory of architectural photogrammetry and architectural survey of the Mediterranean Laboratory of “Survey and Diagnostics for Architecture” of the University of Catania, for his assistance during the phases of on-site survey.

CREDITS

Despite the joint nature of the research work carried out, the editorial responsibility for the paragraphs is attributed to: paragraph 1, Franca Restuccia; paragraphs 2 and 5, Corrado Fianchino; paragraph 3, Mariateresa Galizia; paragraph 4, Cettina Santagati.

REFERENCES

- “Carta geologica della Sicilia sud-orientale 1/100.000, Università di Catania, Istituto di Scienze della terra, Selca, Firenze 1984.
- D’Aurea V., (2008), *I “trulli” di Polignano a Mare (Ba). Costruzioni a secco e società moderna: la sfida della conservazione*, in Bollettino Ingegneri Toscana, n. 11.
- Fianchino C. (1983), “Caratteri tecnologici della ricostruzione settecentesca nella Sicilia sud-orientale”, Documento 7 I.D.A.U., Catania, footnote 12.
- Fianchino C. (1988), *Le Pietre nell’Architettura*, Documento 15, I.D.A.U., Catania, 1988.
- Giandebbiaggi P., (2006), *Rilievo e conoscenza dell’architettura: ricerca delle innovazioni nella tradizione costruita*, in (editors, Bertozzi P., Ghini A., Guardigli L.,) *Le forme della tradizione in architettura. Esperienze a confronto*, Franco Angeli.
- Gulli R., Mochi G. (1997), “Il modello bizantino, La cupola di Santa Sofia a Costantinopoli”, (editor Conforti C.) *Lo specchio del cielo forme significati tecniche e funzioni della cupola dal Pantheon al Novecento*, Electa, Milano.
- Margani G. (2005), “Celle tricolore edifici a pianta trilobata nella tradizione costruttiva siciliana”, Documento 28 D.A.U., Editrice Il Lunario, Enna 2005.
- Rossi G., Leserri M. (2007), *Le geometrie delle architetture in pietra a secco salentine. La cupola in oggetto*, in Atti del quinto forum internazionale di studi “Le vie dei mercanti Rappresentare il Mediterraneo”, Capri 14-15-16 giugno 2007. La scuola di Pitagora editrice, 777-782.
- Santagati C. (2009), *Il rilievo mediante laser scanner 3D. Problemi di metodo e procedure inerenti ai beni archeologici e paesaggistici*, in AA.VV. *Il modello digitale per il progetto: l’esperienza del parco archeologico di Kaukana a Santa Croce Camerina (RG)* Sesto congresso UID XXXI Convegno Internazionale delle discipline della rappresentazione - Disegno e progetto - Lerici 13,14,15 ottobre 2009.
- Santagati C. (2011), “Metodologie digitali per il disegno delle torri di Enna”, in Galizia M., *Il disegno delle torri medievali di enna nel paesaggio urbano tra passato e presente*, Giuseppe Maimone Editore, Catania, pag 129-160.
- Tiralongo P. (2006), *Pietra su Pietra architettura in pietra a secco degli Iblei*, EdiARGO, Ragusa,
- Trapani F., (2008) “La ‘Favorita’ presso l’Asinaro. A proposito della cristianizzazione del Mediterraneo Occidentale. Alcune considerazioni.” In Progetto KASA 2, sito www.progettoKasa.net.

Figure 4. Fianchino, 1988 pp. 104,125

Figure 5. Tiralongo, 2006 pp 124-122-121-125-127-128

Figure 6. Tiralongo, 2006 pp 98-106 -104-84

Figure 17. Gulli R, Mochi G., 1997 pag.46

Figure 18. Margani G, 2005 pag 47

Figure 19 -20. Trapani, 2008 pag.338