THE "BAROQUE SKYLINE" IN NAPLES. STRUCTURAL STUDIES ON 16TH AND 17TH CENTURY DOMES IN TERMS OF FORM AND STABILITY

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Abstract

Introduction: Walking through the streets of the historic center of Naples and taking a glance at the sky, you may notice that its skyline is determined by the countless peculiar architectural elements, the domes precisely, that stand out from the context. **Purpose of the study:** The study aims to investigate the Neapolitan domes of the 16th and 17th centuries, focusing on the role of geometry and the close relationship between form and stability in the construction of this type of vaulted structures. **Methods:** Geometric surveys and in-situ investigations are used to define the shape of the domes. The study of the constructive solutions is based on the analysis of the original documents describing the works carried out as well as the analysis of several structural components that constitute the domes. This is related to ancient treatises and comparison, as far as possible, with similar buildings. Finally, to describe the mechanical behavior of these constructions, reference is made to the Modern Limit Analysis Theory developed by J. Heyman and applied to masonry structures in order to determine their degree of safety. **Results:** The approach set out can help to avoid improper restoration interventions on such historical artefacts. For good restoration work, it is absolutely indispensable to deeply investigate the geometrical and constructive aspects of a building, as well as its mechanical properties, in order to avoid approaches and methods of structural analyses far from the real behavior of these masonry structures.

Keywords

Baroque, construction history, masonry domes, limit analysis, restoration.

1. Introduction

The domes in Naples represent a cultural asset scattered throughout the city and characterized by precise examples belonging to several historical periods that contribute to testify the different construction phases of the urban context. Among all of them, the present work focuses on the Neapolitan domes of the Baroque period. Numerous studies have been previously conducted on this topic. Since 1998, some researches, carried out in Naples, have concerned the domes. In that year, a study was performed by a group of researchers, coordinated by Salvatore Di Pasquale, in order to promote a multidisciplinary approach involving not only historians but also experts in structures. Later, in 2005, another research was carried out, funded by the Ministry of University and Research, on the domes in Campania (Casiello, 2005), where they reported cognitive investigations and issues of conservation, and also, a further research program on the dome structures between the 15th and 16th centuries in Campania is being carried out coordinated by prof. Valentina Russo (de Martino, 2017). To date, these investigations are mainly focused on the historical and restoration aspects as well as the drawing and representation of vaults and domes resulting in the fragmentary and compartmentalized form, without belonging to a broader cognitive field concerning the cultural heritage. More than in other Italian cities, the Neapolitan Baroque is marked as a period of transition from the certainties of the 16th century to the doubts of the 17th century with tensions that are reflected in the architectural language. All this information, which can be deduced from a detailed analysis of these historical compounds, must converge in the same process aimed at the transmission of values and the conservation of the buildings. Namely, when dealing with the substantial separation between compositional aspects (formal, spatial) of buildings and structural ones, which appears from contemporary studies on this issue, there is a need for an interdisciplinary approach to assess the stability of these historical structures and avoid inappropriate consolidation intervention. The study aims to contribute enriching the knowledge on design and construction techniques adopted for the domes built in the Neapolitan Baroque period, whose studies up to now are still incomplete. The innovative character of the research is configured to contribute to broadening the knowledge of these architectural elements by making available to the scientific community the proper tools to intervene in a not invasive manner on these historical artefacts and to deal with the problem of preservation of the architectural heritage.

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2. Literature review: notes on the Neapolitan background

A complete understanding of historic buildings — how these structures were designed by their builders, the knowledge of their positioning and the rules used for the dimensioning of the structural elements — is necessary to conduct correct static analyses by employing currently available means and, at the same time, absolutely consistent with the original design of the structure (Cusano, 2019). In this section, with a special emphasis on the Neapolitan context, an excursus on the historical premises that characterized the development of theories and methods for the study of historical structures in masonry is presented, with remarks regarding the contribution given during the centuries by treatises. Traditionally, the ancient master builders used structural rules (geometric and arithmetic) to size the constructions. Knowledge of the fundamental properties of masonry structures was acquired by the experience in construction and by the use of scale models: the set of rules and their fields of application constituted, in every age, the 'theory of structures' (Huerta and De La Cuerda, 1998). At the end of the 17th century, the science of mechanics had acquired sufficient development and scientific justification for these technical processes was needed. As known, the birth of the analysis of masonry vaulted structures occurred at the end of the 17th century, in England (Robert Hooke and the theory of the catenary) and France (De La Hire, Bélidor) at the same time. In the 18th century, the coexistence between the traditional calculation and the scientific one, that began in the 17th century and lasted till a time when masonry dome constructions were abandoned at the beginning of the 20th century, continued. Architects and engineers with more scientific background feel, more and more, the need to justify their projects according to the laws of mechanics. However, conscious or unconscious, the reference to the validity of their theories and their calculations can be found in traditional rules, coding the proportions of existing buildings. The next major step in the theory of masonry arch takes place in the second half of the 20th century and consists in the application of the recently developed limit analysis (Heyman, 1966, 1995).

In the Neapolitan context, numerous studies and essays show the greatest attention to this topic by scientists who deal with the study of the behavior of domes both in general terms and with reference to specific monuments (Aveta, 2005). Among these, the essays by G. A. De Fazio (1813), N. D'Apuzzo (1831), and those by F. P. Tucci (1832, 1884) are cited (Figure 1). In the D'Apuzzo's treatise, the most advanced studies in the research of the pressure curve are also mentioned; in particular, he refers to the studies performed by De La Hire, Frezier, Durand, Gauthey, Couplet, Perronet and Mascheroni. The re-edition of the treatise by N. Cavalieri San Bertolo (1840) is also published in Naples, focusing on the distribution of technical culture.

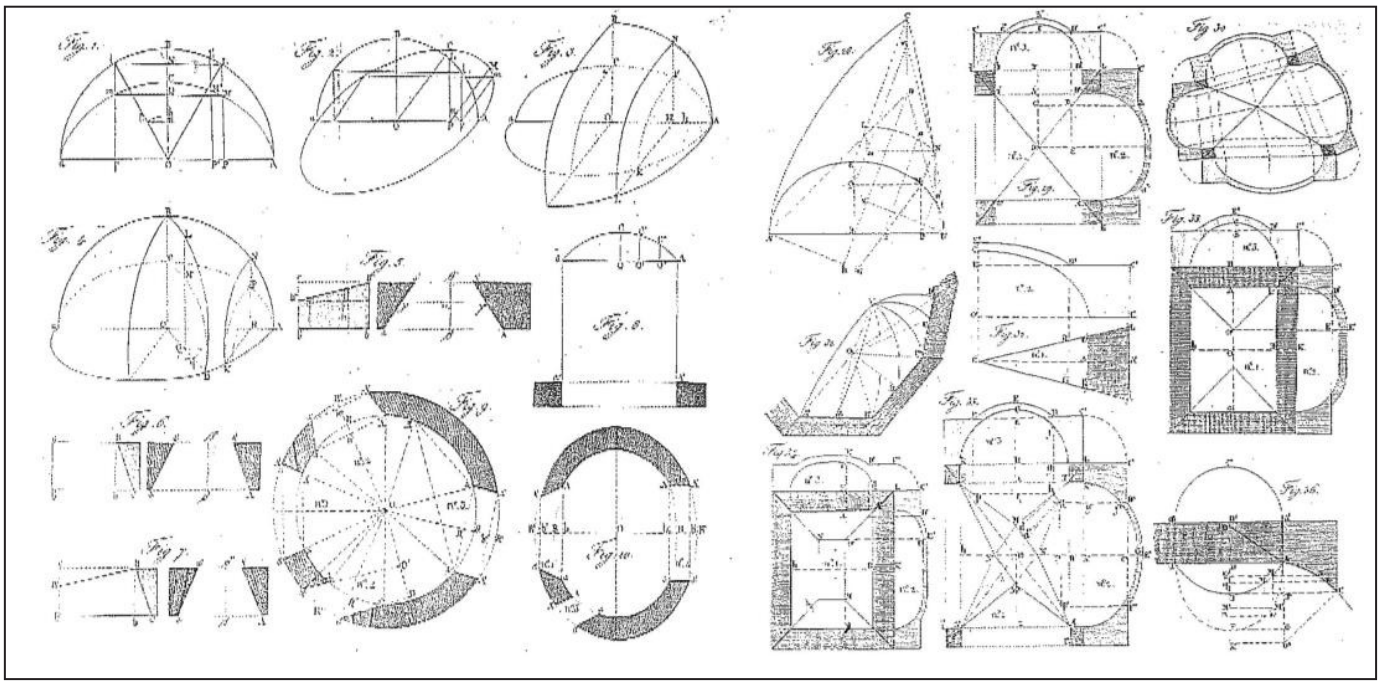

Figure 1. F.P. Tucci. Della misura delle volte rette ed oblique, Napoli 1832, Tav. I and Tav. IV.

Exactly one century earlier, the most important scientific writings concerning structural topics were written in Naples by Vincenzo Lamberti and Nicola Carletti.

V. Lamberti wrote his *Statica degli edifici* (Lamberti, 1781), in which he discusses the issue of construction theory in Naples at the time. In the last part of his essay, the author focuses on the possible causes of static failures in buildings by detecting, among them, weakness of foundations, shaking, overload, bad construction practice, and ancientness (Figure 2). Lamberti also introduces a

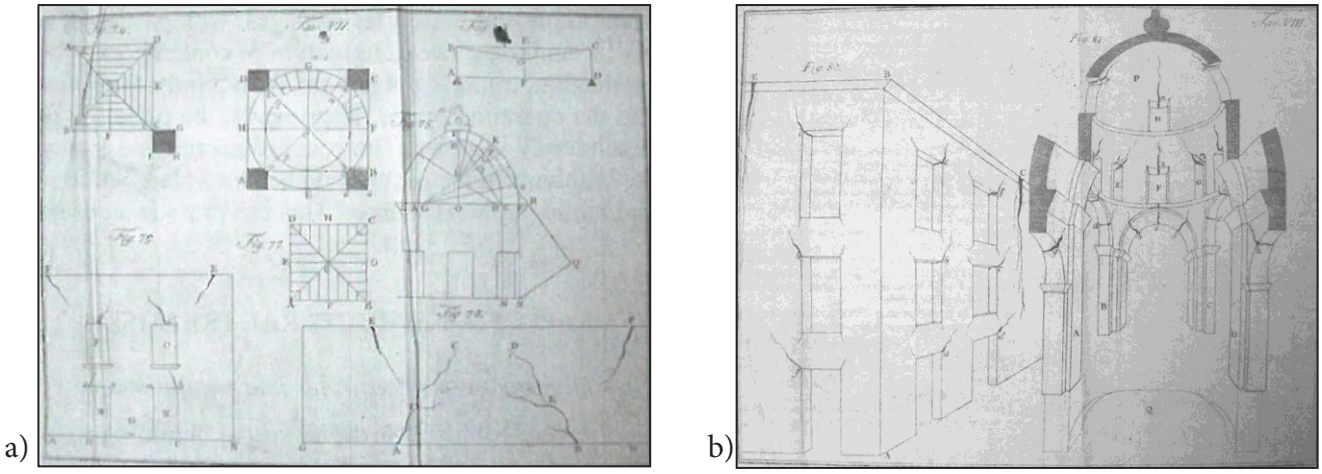

Figure 2. V. Lamberti. *Statica degli edifici.* (a) Tav. VII, (b) Tav. VIII.

corresponding type of cracking for each of the identified causes and, even if the problem of vaulted structures is not specifically dealt with, the case of cracking in arches bearing a dome is addressed (De Martino and Russo, 2005).

Carletti also addressed the study of domes, focusing on the risks associated with this type of structure, which he considered "by nature, light, imperfect, expensive and dangerous" being the result of a "joint of several pointed arches". He classifies these structures into dome vaults and hemispherical vaults on the basis of their resistance to vertical stresses.

In the second half of the 19th century, the contribution of E. Folinea (1855) can be mentioned: in his essay, he focuses on the interpretation of the crack pattern of ancient buildings and the most adopted restoration interventions. He also studies the problem of damage caused by horizontal thrusts in buildings covered by masonry vaults. In 1855, the treatise of F. De Cesare was published, in which the knowledge on the construction of the vaults was developed in a fairly complete way. In his work, there are references to the evolution of the theories of their proportioning, with reference to the Rondelet's work. Interesting is the constructive aspect dealt with in his essay: the classifications of the masonry vaults are related to the typical aspects of the local building traditions (e.g. *volte leggiere* — tile vaults or plaster vaults).

3. Overview of baroque domes in Naples

Numerous studies carried out on the topic show that it is possible to count approximately 80 domes in Naples in the urban area extending on the north-south side from Capodimonte to the sea and on the east-west side from the business center to Mergellina (Baculo Giusti, 1999). The presence of so many domes, starting from the Renaissance treatises in the Neapolitan scenario, is evidence of the sacred history of the city. The practice of religious orders to delineate a space, an island, within the structure of the historical city can be noted, when over years the domes become the indicator of their presence in the territory. It is enough to take a look at the view of Naples by F. B. Werner and H. J. Wolff dating back to the beginning of the 18th century (Figure 3) and the 18th century topographic map by the Duke of Noja Giovanni Carafa (Figure 4) to appreciate the number of domes in the city.

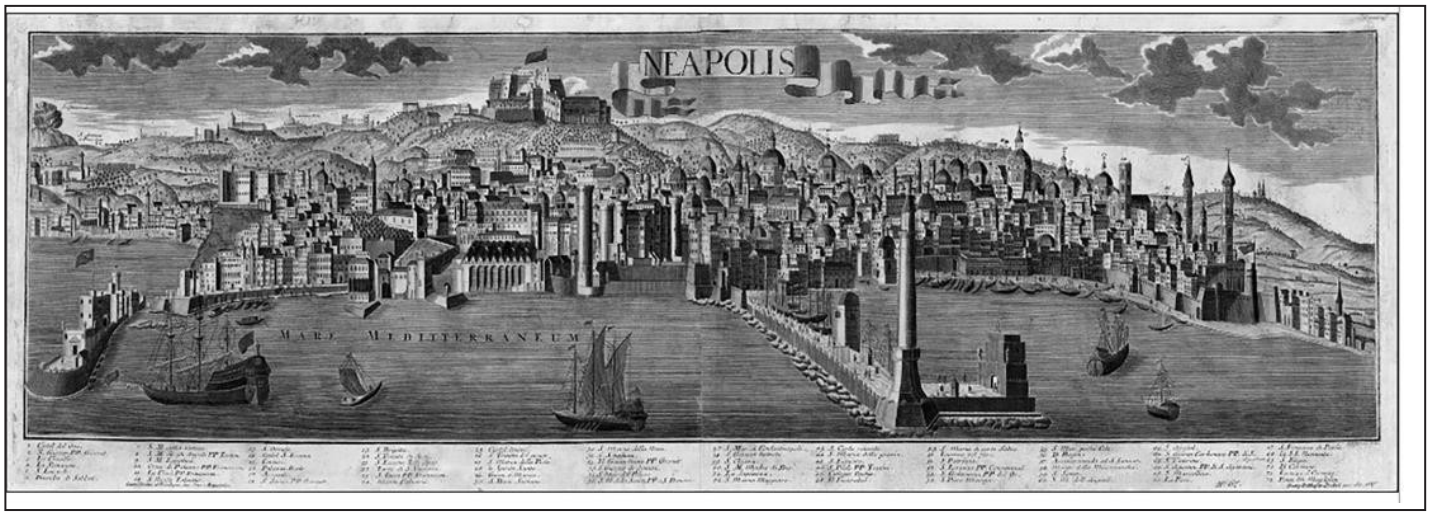

Figure 3. Striking large-format view of Naples, showing the town from the harbor. This is the second (of three) editions. The first includes the name Jerimiah Wolff. The credit indicates that the view was newly engraved by F. B. Werner. Photo: Barry Lawrence Ruderman. Antique Maps Inc.

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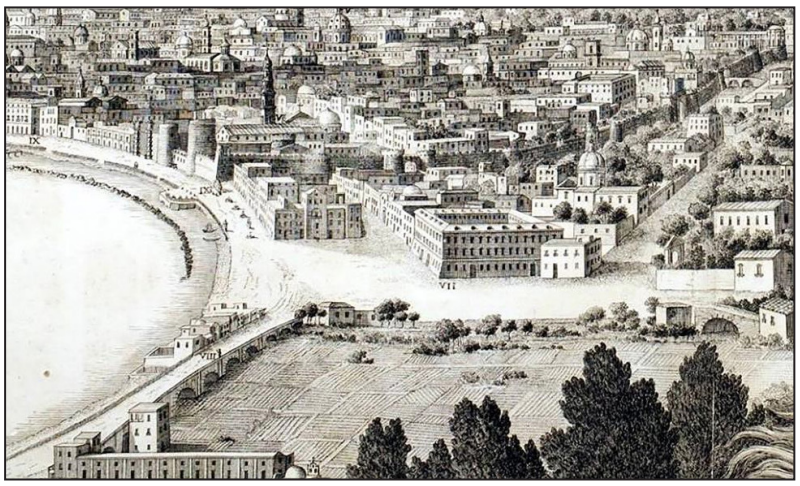

Figure 4. Giovanni Carafa Duke of Noja (1775). *Mappa topografica della città e de' suoi contorni.* Details of Tav. 27 in which the domes of the eastern part of the city can be identified.

The Neapolitan 17th century is characterized by disastrous episodes such as the earthquakes that occurred in 1627, 1688, and 1694. The two earthquakes of 1688 and 1694 caused significant damage to the architectural heritage, which was already in precarious static conditions. As a consequence, numerous consolidation works were undertaken, which often also made formal changes to the monuments. Without any doubt, it can be said that the greatest number of restorations of churches can be attributed precisely to the 17th century, including the construction of the presbytery, transept and, above all, the addition of the dome as a structural element (Casiello, 2005).

Figure 5 shows the location in plan of the domes surveyed in Naples (Baculo Giusti, 1999), and, among all of them, the domes dating back to the Baroque period, which contributed to defining the context of the ancient Neapolitan center, are highlighted in rectangles.

Figure 5. Map of the city of Naples: graphic elaboration by A. Scorpinti (Baculo Giusti, 1999). The image shows the location in plan of the surveyed domes; underlined by the authors are the baroque domes.

3.1 Structure

The study of Neapolitan Baroque domes started from a systematic collection of documents concerning previous studies. The information therein was then classified according to geometric, constructive and mechanical aspects.

3.1.1 Dome geometry

As known, geometry is the main aspect that comes into play when analyzing a historic masonry structure. From the first reading, it is possible to deduce that most of the domes detected are circular in plan, extradosed and have a simple shell. Among them, we distinguish:

- domes without a lantern, with a drum (raised-arch dome, rounded-arch dome) such as St. Maria della Colonna (Figure 6a);
- domes without a lantern, without a drum (lowered-arch dome) such as SS. Trinità dei Pellegrini (Figure 6b);
- domes with a lantern, with a drum (raised-arch dome, rounded-arch dome, lowered-arch dome) as the case of SS. Annunziata (Figure 6c);
- the only dome with a lantern and without a drum (lowered-arch dome) — St. Angelo a Nilo (Figure 6d).

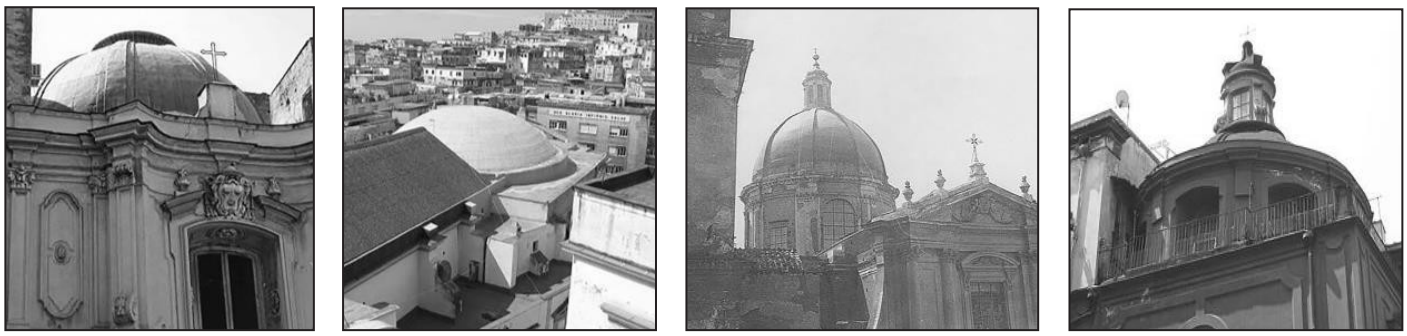

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Figure 6. (a) The dome of St. Maria della Colonna without a lantern, with a drum; (b) the dome of SS. Trinità dei Pellegrini without a lantern, without a drum; (c) the dome of SS. Annunziata with a lantern, with a drum; (d) the dome of St. Angelo a Nilo with a lantern and without a drum (Casiello, 2005).

In a smaller number, but still present, are the domes that are circular in plan, with a double shell, extradosed, with a lantern (with or without a drum) (Figure 7a). There is no shortage of elliptical domes, all of which consist of a simple shell, are extradosed and with a lantern (with or without a drum) (Figures 7b and 7c).

Figure 8 provides a diagram summarizing the first classification of the surveyed domes according to the major geometrical and typological parameters.

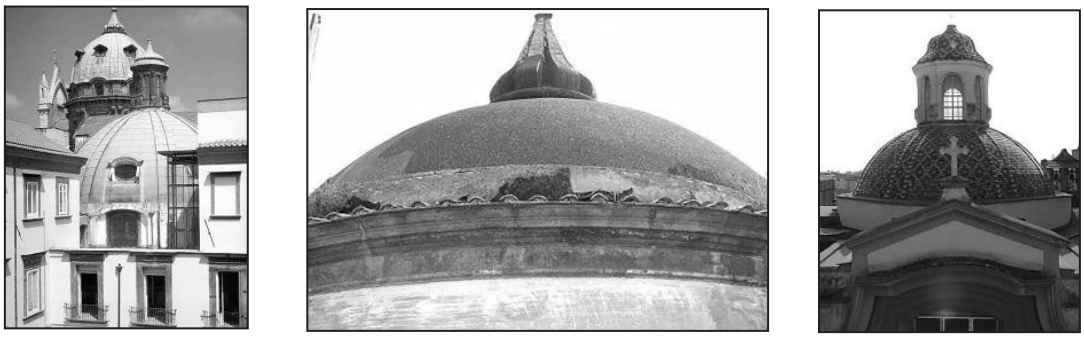

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Figure 7. (a) The dome of Pio Monte della Misericordia with a lantern, with a drum; (b) the dome of SS. Trinità dei Pellegrini with a lantern, with a drum; (c) the dome of St. Maria del Popolo agli Incurabili with a lantern, with a drum (Casiello, 2005).

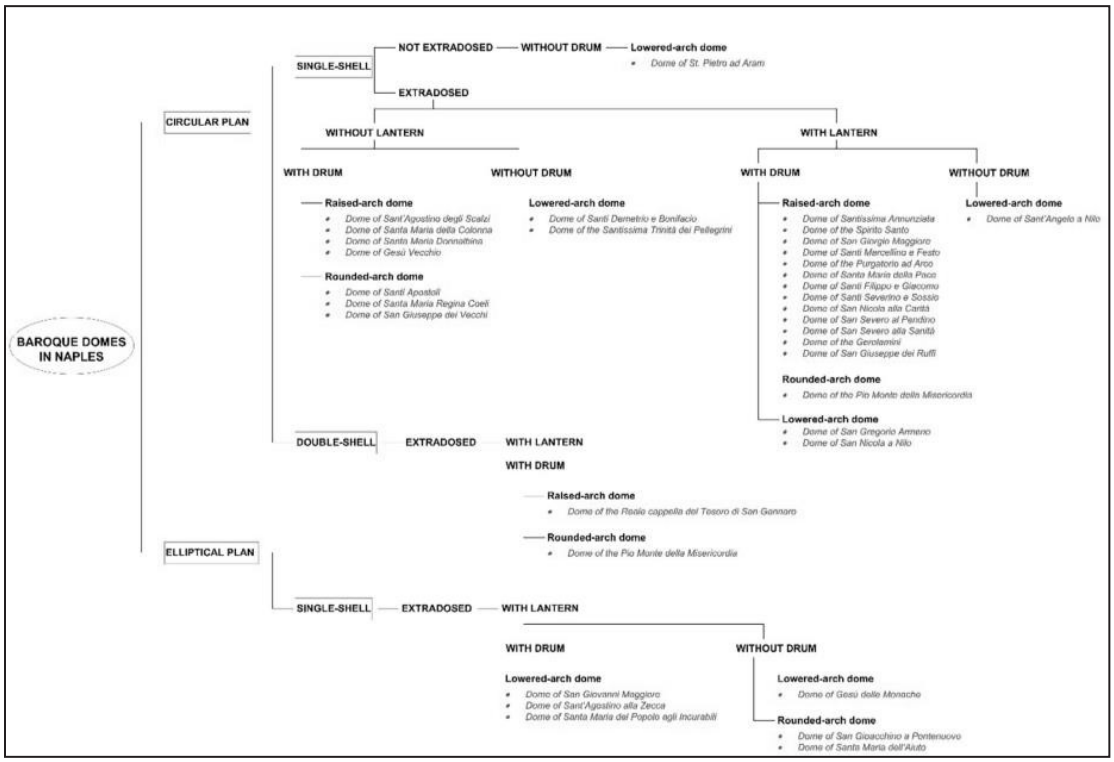

Figure 8. Classification of the surveyed domes according to the major geometrical and typological parameters (diagram by the authors). It also shows a list of the domes, with their names, organized by categories.

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3.1.2. Construction features

The second classification of baroque domes may refer to the materials and construction techniques used for their realization. The Neapolitan building tradition of the period between the 17th and 18th centuries includes the widespread use of cutting stone and stone chipped (*a scheggione*) as well as domes made by concretion and ribbed (Renzullo, 1999). Tuff or Vesuvian stones were the main materials used. The tuff ashlars were worked in the form of wedges and connected by mortar joints; the Vesuvian stones, much more regular, allowed a perfectly fitting laying surface that did not require mortar, except for a small surface cover during placement. Due to the great availability of stones in the form of chips, domes of limited size could be built. Concrete domes, on the other hand, derive from a tradition dating back to the Romans. This construction technique did not involve the use of stone ashlars but a conglomerate of lime mortar and *pozzolana* together with tuff or volcanic stone chips. Subsequently, this method was improved with the introduction of meridian ribs as well as discharge arches along the parallels. The baroque aspect of the Neapolitan domes can be clearly seen in the exterior (Penta, 1999). In fact, it was customary to cover the extrados of the dome with polychrome majolica, a formal solution of oriental influence (Arabic art).

The distribution of the majolica tiles was attributed to architect Giuseppe Donzelli, known as Fra' Nuvolo (Figure 9a). This covering was made by means of majolica tiles arranged according to crossed diagonals to form a grid. The fixing of these roof tiles was provided by spikes and mortar. Since the 1600s, it was typical to use copper and lead coating, which also helped to ensure protection against corrosion due to atmospheric agents (Renzullo, 1999). Among the most significant examples of lead covering, we can mention the dome of Girolamini (Figure 9b) and Sant'Agostino agli Scalzi.

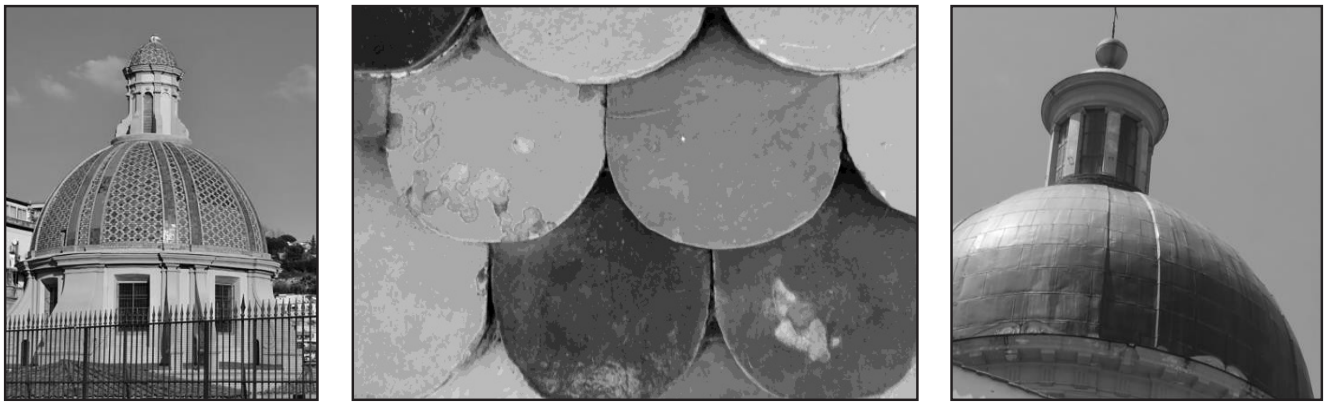

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Figure 9. (a) The dome of St. Maria della Sanità in Naples; (b) details of majolica roof tiles; (c) the dome of Girolamini in Naples. Photo by José Maria Gonzales Spinola in Vesuvioweb, October 11, 2013.

3.1.3. Stability (masonry mechanics)

One of the most important factors that concern numerical modeling of masonry structures is the estimation of mechanical properties of the material; on the other hand, the characterization of the geometry of these types of construction typologies is a significant problem (Cennamo et al., 2017a). In order to know the mechanical behavior of these structural elements, reference is made to the Modern Limit Analysis Theory applied to masonry structures, to assess their degree of safety and interpret the changes they have undergone (Cennamo et al., 2017b).

As known, masonry constructions are built with a material that satisfies three conditions. Firstly, the tensile strength in masonry is zero; in particular, the mortar joints in masonry have no tensile strength: this is in favor of safety considering that there is always a certain adherence to the mortar. Secondly, the masonry material works in compression: the tensions are so low that the compressive strength can be considered as infinite; thus, material strength properties are not of concern. Finally, a sliding failure cannot occur. Under these conditions, the material complies with standards and the fundamental principles of limit analysis can be observed for masonry (Cennamo et al., 2018a; Heyman, 1995). Within the framework of Limit Analysis, the fundamental Safe Theorem states that if any equilibrium state can be found, for which the structure is purely compressed, then the structure is stable, so a collapse can never occur under the given loads (Huerta, 2004). For stable masonry structures, there are infinitely many states of equilibrium that do not violate the hypotheses for the material. Some of them can be represented either by a family of lines of thrust (Cennamo et al., 2019; Cusano et al., 2018) or by membrane stress states (Cennamo et al., 2018b; Cennamo et al., 2018). Many authors (Cennamo and Cusano, 2018; Cennamo et al., 2017) refer to the application of limit analysis to arches, vaults, and domes.

4. Discussion

As already mentioned above, this article presents a research work in progress. The current state concerning the topic of the Neapolitan Baroque domes has been

retraced as a starting point for future studies on historical heritage preservation. No one has ever claimed to exhaust the complexity of such a quantitatively varied and significant casuistry.

The aim was rather to underline what a lack of knowledge of such elements' values can produce, on the one hand, and, on the other hand, to implement a multidisciplinary program providing a solid background when it is necessary to intervene on these historical artefacts. Even the issue of mechanics, which has always been neglected in the studies conducted so far, is a key factor for the authors to understand how these constructions were conceived by engineers and architects of the past. From this point of view, structural treatises may provide useful information about the knowledge acquired by ancient builders in order to plan their structures. For good restoration work, it is absolutely indispensable to deeply investigate the geometrical and constructive aspects of a building, as well as its mechanical properties, in order to avoid approaches and methods of structural analyses far from the real behavior of these masonrystructures.

It is necessary to point out that the static history of any ancient construction should be particularly attentive to less conspicuous aspects and should make use of archival and bibliographical sources to obtain useful information about materials provenance, construction techniques and consolidation methods. The interrelationship between in-situ inspections and historical investigations may help to choose specific solutions to be adopted (De Martino and Russo, 2005).

5. Conclusions and future works

The architecture of the 16th and 17th centuries in Naples shows remarkable features that arise directly from the building techniques used for the construction of vaults and domes. Starting from the state of the art, from the list of the domes surveyed in the Neapolitan area and their planimetric location, the objectives of the future research works are manifold.

Firstly, it seems necessary to conduct the archival and bibliographic research for those domes, of which there is little (or no) information for the reconstruction of the building stages of the artefact. For the domes already extensively documented from a historic point of view, the useful information shall be duly selected to define a complete framework on the constructive techniques adopted to build them. The investigation also aims to compare different domes belonging to the same historical period in Naples (and not).

As known, the geometrical surveys and laser scanning for those domes, of which there is no information yet, as well as the study of the geometry, dimensional aspects, and typology are a part of the complete knowledge of the building. Thus, the ultimate goal is to conduct a study on the stability of the domes, applying limit analysis combined with the graphic statics, bearing in mind that the methods used today to analyze masonry structures, based on FEM and elastic theory, are not suitable for these kinds of structures, for which only the geometry (stability) needs to be controlled in the analysis process.

References

Aveta, A. (2005). L'approccio multidisciplinare per la diagnosi dei dissesti strutturali di volte e cupole. In: *Casiello, S. (ed.) Le cupole in Campania. Indagini conoscitive e problematiche di conservazione.* Napoli: Arte Tipografica Editrice, pp. 37–85.

Baculo Giusti, A. (1999). Bellezza tra continuum ed emergenze. Il ruolo delle cupole nella città di Napoli. In: *Baculo Giusti, A. di Luggo, A. and Florio, R. (eds.) Napoli versus coleum. La città e le sue cupole.* Napoli: Electa, pp. 1–20.

Bélidor, B. F. (1725). *Nouveau cours de Mathématique a l'Usage de l'Artillerie et du Génie ou l'on applique les parties les plus utiles de cette Science a la Théorie et a la pratique des différens sujets qui peuvent avoir rapport a la Guerre.* Paris: Chez Charles-Antoine Jombert, 560 p.

Bélidor, B. F. (1813). *La science des ingénieurs dans la conduite des travaux de fortification et architecture civile.* Paris: Firmin Didot, 596 p.

Casiello, S. (2005). *Le cupole in Campania. Indagini conoscitive e problematiche di conservazione.* Napoli: Arte Tipografica Editrice, 407 p.

Cavalieri San Bertolo, N. (1840). *Istituzioni di Architettura Statica e Idraulica.* Napoli: Presso Caro Batelli, 276 p.

Cennamo, C. and Cusano, C. (2018). The gothic arcade of Santa Maria Incoronata in Naples. Equilibrium of gothic arches. *International Journal of Masonry Research and Innovation*, 3 (2), pp. 92–107. DOI: 10.1504/IJMRI.2018.092454.

Cennamo, C., Cusano, C. and Angelillo, M. (2017a). Structural failures due to anthropogenic sinkholes in the urban area of Naples and the effect of a FRP retrofitting. *Composites Part B: Engineering*, 108, pp. 190–199. DOI: 10.1016/j.compositesb.2016.09.043.

Cennamo, C., Cusano, C. and Angelillo, M. (2017b). The neoclassical dome of San Francesco di Paola in Naples. A study on form and stability. In: *Edizioni, G. (ed.) Proceedings of the XXIII Conference of the Italian Association of Theoretical and Applied Mechanics*, Salerno, Italy, 4–7 September 2017, Vol. 4, pp. 1439–1448.

Cennamo, C., Cusano, C. and Angelillo, M. (2018a). On the statics of large domes: a static and kinematic approach for San Francesco di Paola in Naples, In: *Proceedings of the British Masonry Society,* Milan, Italy, July 9–11, 2018, pp. 504–517.

Cennamo, C., Cusano, C. and Angelillo, M. (2018b). Seismic vulnerability of domes: a case study. *Journal of Mechanics of Materials and Structures*, 13 (5), pp. 679–689.

Cennamo, C., Cusano, C. and Angelillo, M. (2019). A limit analysis approach for masonry domes: the basilica of San Francesco di Paola in Naples. *International Journal of Masonry Research and Innovation*, 4 (3), pp. 227–242. DOI: 10.1504/IJMRI.2019.100568.

Cennamo, C., Cusano, C. and Guerriero, L. (2017). The slicing technique for the evaluation of the formal efficiency: a comparative study. In: Edizioni, G. (ed.) *Proceedings of the XXIII Conference of the Italian Association of Theoretical and Applied Mechanics,* Salerno, Italy, 4–7 September 2017, 4, pp. 1544–1554.

Cennamo, C., Cusano, C., Angelillo, M. and Fortunato, A. (2018). A study on form and seismic vulnerability of the dome of San Francesco di Paola in Naples. I*ngegneria Sismica,* 35 (1), pp. 88–108.

Cusano, C. (2019). *La cupola di San Francesco di Paola. Geometria, costruzione e stabilità nel progetto di cupole nella prima metà del XIX secolo. PhD Thesis in Architecture.* Caserta: University of Campania Luigi Vanvitelli.

Cusano, C., Cennamo, C. and Angelillo, M. (2019). Stability analysis and seismic vulnerability of large masonry domes. *Masonry International,* 32, pp. 55–62.

D'Apuzzo, N. (1831). *Architettoniche considerazioni.* Napoli: del Fibreno, 335 p.

De Cesare, F. (1856). *La scienza dell'Architettura applicata alla costruzione, alla distribuzione, alla decorazione degli edifici civili*. Napoli: Dai tipi di Giovanni Pellizzone, 272 p.

De Fazio, G. (1813). *Discorso intorno all'architettura degli archi di trionfo con l'applicazione ad un progetto.* Napoli: Angelo Trani, 24 p.

De La Hire, P. (1712). Sur la construction des voûtes dans les édifices. In: *Mémoires de mathématique et de physique de l'Académie royale des sciences de Paris.* Paris: Académie royale des sciences, pp. 70–78.

De Martino, G. (2017). *Tra paesaggio e ambiente costruito: cupole in Campania.* BDC, 17, pp. 269–278.

De Martino, G. and Russo, V. (2005). Structural damage prevention in the historical building site. Theory and praxis in the eighteenth century in Campania. In: *Modena, C.,Lourenço, P. B. and Roca, P. (eds.) Structural analysis of historical constructions.* London: Taylor & Francis Group, pp. 153–158.

Folinea, E. (1855). *Sulle origini delle lesioni nei fabbricati e metodi di restauro.* Napoli.

Heyman, J. (1966). The stone skeleton. *International Journal of Solids and Structures,* 2 (2), pp. 249–279. DOI: 10.1016/0020-7683(66)90018-7.

Heyman, J. (1995). *The stone skeleton: Structural engineering of masonry architecture.* Cambridge: Cambridge University Press, 160 p.

Huerta, S. (2004). A*rcos, bóvedas y cúpulas. Geometría y equilibrio en el cálculo tradicional de estructuras de fábrica.* Textos sobre teoría e historia de las construcciones. Madrid: Instituto Juan de Herrera, 623 p.

Huerta, S., De La Cuerda, R. H. (1998). La teoría de bóvedas en el siglo XVIII: La contribución de Philippe de la Hire. In: *Bores, F., Fernández, J., Huerta, S. and Rabasa, E. (eds) Actas del Segundo Congreso Nacional de Historia de la Construcción, Coruña, October 22–24,* 1998. Madrid: Instituto Juan de Herrera, CEHOPU, Universidad de la Coruña, pp.233–244.

Lamberti, V. (1781). *Statica degli edifici in cui si espongono i precetti teorici pratici, che si debbono osservare nella costruzione degli edifici per la dura ta di essi.* Napoli: Giuseppe Campo. 260 p.

Penta, I. (1999). Gli embrici maiolicati. In: *Baculo Giusti, A., di Luggo, A. and Florio, R. (eds.) Napoli versus coelum. La città e le sue cupole.* Napoli: Electa, pp. 97–100.

Renzullo, A. (1999). Le cupole della città di Napoli: una campionatura. In: *Baculo Giusti, A., di Luggo, A. and Florio, R. (eds.) Napoli versus coelum. La città e le sue cupole.* Napoli: Electa, pp. 75–81.

Tucci, F. P. (1832). *Della misura delle volte rette ed oblique: trattato teorico e pratico.* Napoli. 56 p.