Geotechnical Engineering for the Preservation of Monuments and Historic Sites III

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Form and construction. The domes of the Baptistery and Santa Maria del Fiore in Florence

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ABSTRACT: Each building requires specific surveys and appropriate instrumental investigations which are often indicated during the course of the analyses. The activities that form part of the architectural and structural diagnostics must aim to identify the actual construction site activities, in operational terms, that over time have generated and altered the architectural structure.

In this regard, the dome of the Baptistery of Florence is particularly significant. It has been the subject of countless studies that have provided different interpretations of the structure. The initial highly idealised approach provided schematic constructive structures. The gradual refinement of the inspections defined a completely different construction concept of the dome from that established up until recently.

This new information also had a significant impact on the interpretation of Brunelleschi's dome, which showed in an even more compelling way characteristics similar to that of the Baptistery.

1 INTRODUCTION

A feature common to some octagonal segmented domes is a curved intrados profile. A curvature whose radius is almost equal to 4/5 of the diameter of the base was identified in the corners of the dome of Florence Baptistery (Aminti 1996). A pointed profile was also used for the dome of Orcagna's Tabernacle (1359), constructed inside the church of Orsanmichele in Florence (Pisetta & Vitali 1996).

Giovanni di Gherardo da Prato, supervisor of the dome of Santa Maria del Fiore, in 1426 traced on a parchment a drawing with comments criticising the use of the 4/5 radius of the diameter of the base that Brunelleschi was creating in the dome. The precision surveys of the intrados revealed deviations from this curvature (Fondelli 2004). However, for long stretches of the intrados profile, there are strong similarities between the dome of the Baptistery and that of Santa Maria del Fiore (Giorgi 2004, pp. 161–163).

The fact that the curve drawn through 4/5 radius of the diameter was a well-known and widespread device was confirmed by Francesco di Giorgio Martini who mentions it in his Treatise (1479–1486) (Trattati di architettura 1967). The same curvature is also found in the dome of the church of Santa Maria delle Grazie al Calcinaio in Cortona, again designed by Francesco di Giorgio; but the dome was executed by the Florentine architect Pietro di Norbo between 1509 and 1514 (Matracchi 1992).

The two larger domes were built with the initial part in stone and the rest in brick; the other two are entirely made of brick, and stone slabs were added to extrados of that of the tabernacle.

But a mere geometric comparison, also taking into account the building materials, is clearly paradoxical (Figure 1). The different scale of magnitude makes it necessary to acquire more information on the specific construction solutions adopted, which always characterize each building. The construction choices were not only affected by the size of the buildings, but also by local traditions, solutions that could have been brought by builders who grew up elsewhere. The construction phase experimentation that went on above all in buildings of great importance is no less important, and

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there was no shortage of accidental factors that could influence the choices, especially in long-term construction sites.

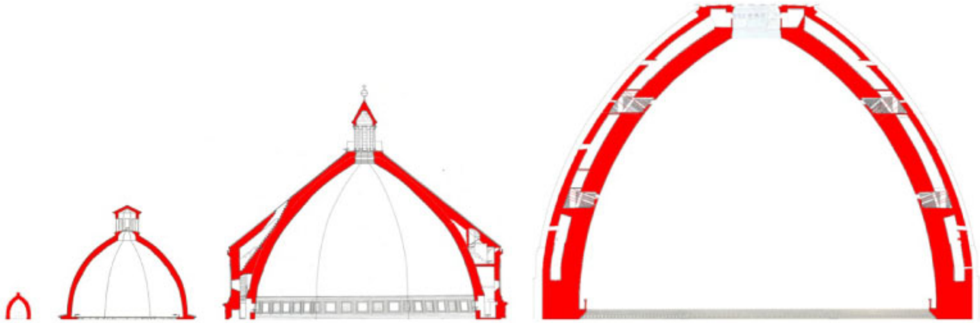

Figure 1. Comparison (from left) at the same scale between the domes of Orcagna's tabernacle, the church of Santa Maria delle Grazie al Calcinaio, the Baptistery and Brunelleschi's dome.

In this regard, a particularly interesting case is Florence Baptistery which, despite having been studied by scholars from the mid-19th century, continues to be analysed in order to obtain important information, to the extent that the constructive structure is evaluated with a profoundly renewed concept.

2 THE BAPTISTERY DOME

Knowledge and in-depth analysis of complex and large dome structures, like that of the Baptistery of Florence, is necessarily a long process linked to the available investigative tools, the conceptual approach guiding the study and the aims to be achieved. If the channel of interest pursued is that of conservation, some construction choices that link the parts to the whole in a holistic vision attentive to the actual act of construction that takes place at the construction site and results in the architectural structure must be explored in-depth. The actions that architecture undergoes over time, which can lead to alterations that are sometimes even substantial, but difficult to identify, are just as important.

The studies of the structure of the Baptistery can be divided into two different seasons. The first is marked by an intuitive approach, which represented the constructional device according to schematic and idealised drawings, which were at times even partial; these representations might have been accurate in graphic terms, but in general they were based on few measurements. They represented what they thought they had understood.

In the drawing by Heinrich Hübsch (1862) the ribs of the dome are envisaged extending until they join the diagonal ribs and the corners of the octagon are solid, but both hypothesis are wrong; the intuition of the box structure at the base of the dome is interesting, with dashed arches indicating the vaulted roofs of each compartment, but there are clear approximations in the dimensions of the masonry (Degl'Innocenti 2017).

The portion of the baptistery dome, depicted by Josef Durm (1887), shows some of the main construction elements, even focusing attention on less striking details. The wall offsets of the extrados at the base of the dome, the transversal walls that divide the various spaces of the garrets, the perimeter wooden tie of the dome, and the vaulted structures supporting the pyramidal roof of the dome are shown. The detail of the internal wall offset was also added to the attic wall.

Auguste Choisy (1899) depicted the dome in a more schematic way in an axonometric drawing, but it has the advantage of showing the entire building highlighting the difference between the section on the sides and on the corner of the octagon; the first shows a considerably hollow structure below the dome due to the presence of columns on the ground floor and the matronea on the level above; the second highlights the massive section of the corners of the octagonal plan, but does not show the hollowing of the wall mass in the area adjacent to the haunches of the dome.

Walter Horn (1943) effectively combines a half section with an axonometric section of one side of the octagon; he thereby highlights the partition walls that flank the dome, the partition walls of the matroneum and, further below, the columns of the internal perimeter (Degl'Innocenti 2017, p. 96).

The drawings prepared by Hübsch, Drum and Choisy are examples, others have also been prepared, of an approach that includes real elements, intuition and interpretations, according to a vision still limited to the arrangement of presumed key construction features, which depict a structural scheme of the building with a high degree of abstraction.

The 1970s marked the start of a new season of studies conducted with increasingly extensive and accurate survey campaigns, more attentive to the analysis of the architectural structure as a whole, the materials and phenomena resulting in the alteration of the latter and the structures. Over time increasing attention was paid to understanding the relationship between the parts and the whole of the architectural device and assessing the construction features, which can vary even in situations of apparent symmetry. The wealth of information collected over time was gradually refined until a cognitive and interpretative synthesis was found based on architectural diagnostics.

So the drawings indicate the portion of the dome, starting from the springer, built with stone in rows that were initially horizontal and that incline from a certain height (Pietramellara 1973). The brick section of the dome is indicated from the wooden tie. In one plan, executed just below the roofs, the partition walls that stand on the extrados of the dome are clearly represented, with the extension of the rampant vaults that support part of the conical roof. Observations on the continuity of the rows of masonry in the garrets, which place the dome, the transversal walls and the external perimeter wall in a close constructive relationship, are particularly important. This structure is considered a "double dome", or a "cellular structure", highly significant concepts, the implications of which have not been explored in-depth, and to which we shall return later on.

Further investigations highlighted the uniqueness of the vertical connections between the monolithic columns, two on each side of the octagon, except for the one where the scarsella is present, and the partition walls of the matronea above, which continue into the garret until becoming the ribs of the dome. In the corners the ribs form a Y-shaped fork that creates the hollowing of the angular buttress at the level of the dome; at the level below, the corner buttress is crossed by a narrow passage necessary to pass through the matroneum, on the ground floor it is solid (Rocchi Coopmans de Yoldy 1996a). The corner buttresses of the east side where the spiral staircases are located are a case of their own. Therefore a system of orthogonal ribs abuts the extrados of the dome at the sides of the octagon, which stand on the intermediate partition walls of the matronea and, further below, on the monolithic columns placed alongside the perimeter walls. The columns had independent foundations with respect to the wall perimeter, with which they slightly overlap. It should be added that the transition between the parallel bearing walls of the matronea and the columns is borrowed from transversal stone lintels, whose modest span between the column and external wall prevented them from being damaged. The Y-shaped ribbing corresponds to the corner pillars.

The construction organisation of the partition walls, in terms of their arrangement and dimensions, nevertheless shows considerable originality linked to the architectural structure of the Baptistery. The three entrance doors imposed a greater intercolumniation than the intervals between the columns themselves and the corner pillars. Indeed, in each of the remaining sides the spaces between the piers are essentially the same. On the sides of the matroneum above the entrances the central mullion windows are considerably wider than those beside them. The accentuation of the central mullion window was repeated on the sides without entrances, moving the parallel transversal walls to the outer edge or the wider lintels below resting on columns; this was achieved by the lintels being wider than the partition walls. Whereas, on the sides of the matroneum above the entrances the gap between the central space and the side spaces reduces, moving the partition walls towards the centre of the side (Figure 2). As a result, the pillars corresponding to the partition wall of the matroneum are not in axis with the columns below (Rocchi Coopmans de Yoldy 1996a, p. 45).

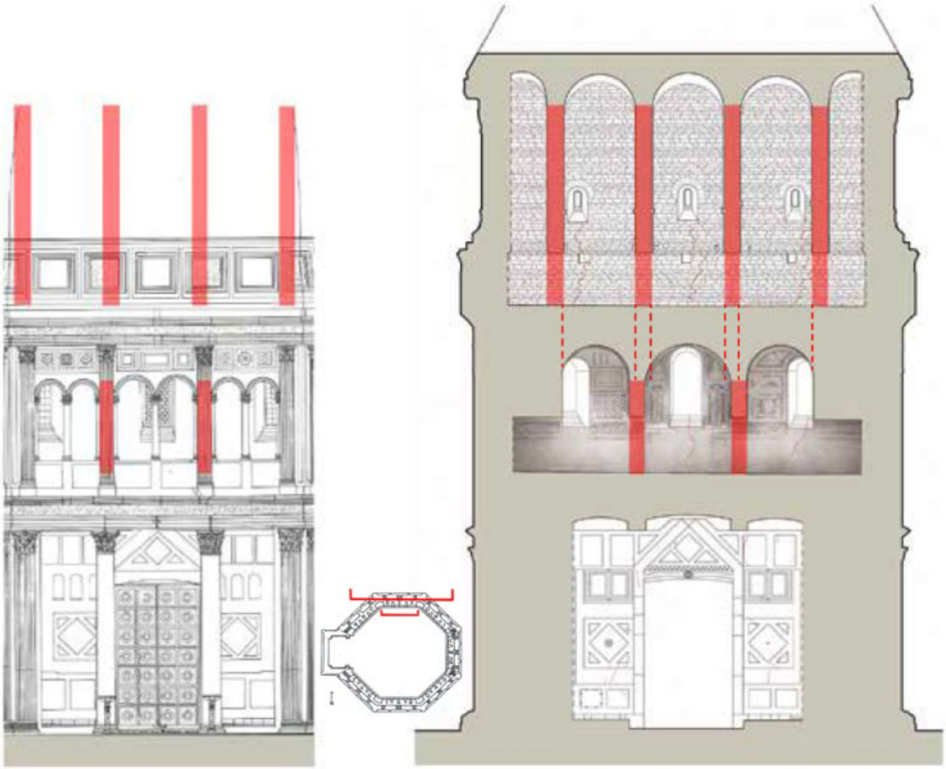

Figure 2. Elevation of the interior north side (left) indicating (in red) the position of the parallel bearing walls; longitudinal section of the north side (right) executed in the intermediate space highlighting the partition walls (in red); the section intercepts the ground floor, the matroneum and the garret.

But these changes in position between structures at different levels are more accentuated in the garret where three compartments of more or less the same width are created on each side (except for the north-west side where the central compartment, with respect to the side ones, is wider by around 30 cm).

Taking the north side into consideration, the two parallel bearing walls of the garrets have an accentuated inward shift, and are positioned outside of the partition walls of the matronea by almost 1/2. The misalignment of the partition walls is borrowed from a sort of wall base which is around 120 cm thick, placed between the transversal barrel vaults of the matronea and the bearing surface of the dome. The difference in the positioning of the structures in this case cannot be visually perceived as it is disguised by the dome, but it is clearly highlighted by the overlapping of the plans and the longitudinal section of the north side. The strong vertical misalignment between the columns and the partition walls is the result of the choice to create three compartments with a similar width close to each side of the dome.

The scarsella side also required specific adaptations, where the continuity of the perimeter wall structure is interrupted. At the base of the dome there are three open windows on each side of the octagon; but on the side above the scarsella it was decided during the works not to complete the two side openings and to infill them (Giorgi & Matracchi 2017). The intention was at least to reinforce the base of the dome, which however exceeded the thickness of the frontal arch of the scarsella. The transverse partition walls and the external perimeter wall completely extended beyond this arch (Giorgi 2004, p. 158). Such impressive structures must not have been placed directly on the vault of the scarsella, but more likely on the relieving arches which rest on the massive adjacent corner pillars of the octagonal perimeter (Figure 3).

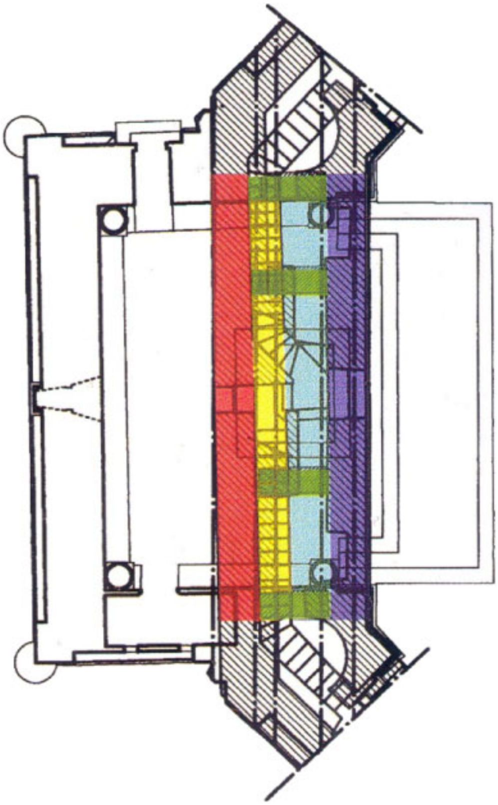

Figure 3. Detail of the plan of the Baptistery with the position of the walls weighing on the vault of the scarsella: the dome (blue), the parallel bearing walls (green), the external wall of the octagonal perimeter (red), (by Giorgi 2004).

Calculation simulations have shown that if the dome had been placed directly on the original vault it would not have been stable due to the small section of this vault (Miceli & Papi 2004). Despite the probable use of reliving arches, the scarsella must have been a vulnerable area from a construction perspective; so the groin vault on columns placed in the corners of the scarsella was added (Figure 4). The geophysical investigations corroborated the existence of two vaults, confirming the use of bricks for the added vault, while the earlier one is made of stone (Morelli 2004).

The further study campaign recently promoted by the Opera di Santa Maria del Fiore produced additional significant cognitive and diagnostic results on different aspects, including some regarding the structures.

The first section of the dome was made with stone ashlars placed in horizontal rows, which with progressive overhangs create the pointed curve of the intrados, while the extrados is vertical (Figure 5). This creates a characteristic reduction of the thickness at the base of the dome: at the springer it is 107 cm, at the summit of the vertical wall it is 130 cm. This level marked the start of a section with offsets on the extrados, until the dome achieves the constant thickness of approximately 103 cm. In the transition zone with wall offsets, the rows of stone start to incline; above, in the north web of the dome, there are small recesses on the extrados which evidence the use of wooden elements used to position the inclination of the rows. The curvature of the intrados established by the centring also generates the inclination of the rows where it is decided to align the rows with the centre, or centres, of curvature of the intrados. This is not the case of the Baptistery dome, where the line of the intrados curve can be distinguished from inclination of the rows.

Figure 4. Transversal partition wall above the scarsella; the crack (in yellow) sealed by vertical plates is visible; the extrados of the dome can be seen on the left.

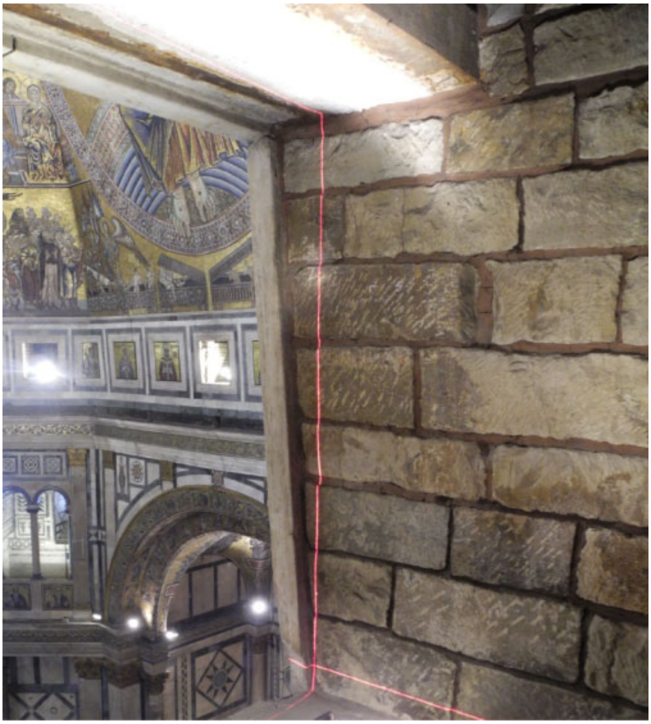

Figure 5. Detail of the dome at the level of the springer. The photo shows the horizontal rows of the masonry positioned with a progressive overhang on the intrados, as shown by the vertical line of the laser.

These latter, in correspondence to the recesses, incline less than the radius of curvature of the intrados of the dome.

The inspection of the top part of the garrets showed that the transversal bearing walls are not adjacent to each other, but are connected with the dome in continuous rows. This results in unique feature: to obtain a better connection between the inclined rows of the dome and the partition walls, for a stretch the rows of the latter are also arranged on an inclined plane (Figure 6), and then become horizontal again, creating masonry in continuous rows with the external wall of the Baptistery (Giorgi & Matracchi 2017, p. 198).

Figure 6. Detail of a partition wall (right) and the extrados of the dome (left) of the Baptistery; the intersection between the vertical and horizontal red lines of the laser highlight the part of the partition wall with masonry in inclined rows perfectly connected with those of the dome.

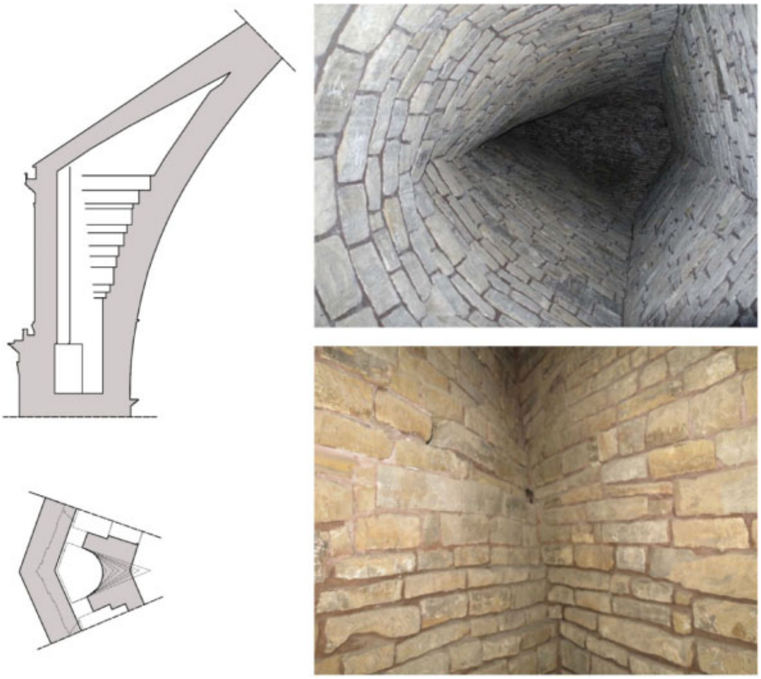

Figure 7. Detail of a corner space at garret level; plan and section with images showing the changes in shape and the continuity of the masonry rows.

The internal wall of the corners of the octagon is shaped as the arc of a circle, a form that follows that of the corners accommodating spiral staircases alongside the east door. In correspondence to the circle arcs of the corners, the thickness of the dome reduces with respect to the sides of the octagon; the dimensions, starting with the south-east side and proceeding in a clockwise direction up to the north-east one, are as follows: 91/90/75/100/89/88 cm. Continuing upwards, the semicircular part becomes triangular, assuming an even more acute angle until creating the Y-shaped fork of the corner ribs. These modifications of the corner spaces are created by maintaining the continuity of the rows for the entire perimeter, except clearly for the base area with the garret crossing points (Figure 7).

The dome, partition walls and external wall therefore create a box structure with continuous rows including the three spaces on each side and the corner compartments. The intention to create a box structure is further confirmed by the fact that this device was extended as far up as possible by means of a constructive expedient created in the corners between the rampant vaults, transversal partition walls and the external wall. The partition walls are covered by stone rampant barrel vaults, on which part of the conical roof of the Baptistery rests, which abut the perimeter wall of the attic. The aim was to prevent the box structure from being interrupted between the partition walls and the external walls at the springer of the barrel vault, in that the radial ashlars of the latter could not have been placed in continuity with the horizontal masonry rows of the lunette of the external wall. Thereby, also exploiting the fact that the vault is rampant, skewed horizontal rows with a progressive overhang were created, which connect to the transversal partition wall and a good part of the edge of the lunette, raising the box structure almost up to the top of the external wall (Figure 8).

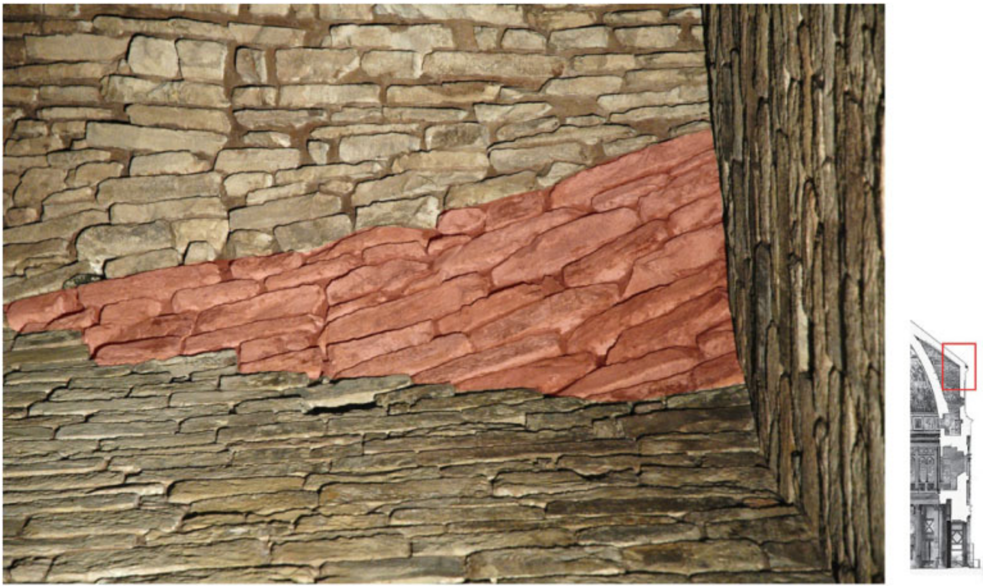

Figure 8. Garret of the Baptistery; detail of the top of the transversal partition wall with the skewed masonry (red) connecting to the edges of the lunette of the outer wall of the attic.

Another distinctive solution linked to the box structure can be found in the external wall: it was reduced to a thickness similar to that of the transversal partition walls (it is just below) and was moved inward creating an overhanging wall offset ending at the bottom with a quarter-circle cornice. The layout with a box structure with symmetrical compartments on each side of the pavilion was pursued with clear intention by the builders, who in order to obtain it had to accept the consequent lack of continuity with the partition walls of the matronea below (Figures 9,10).

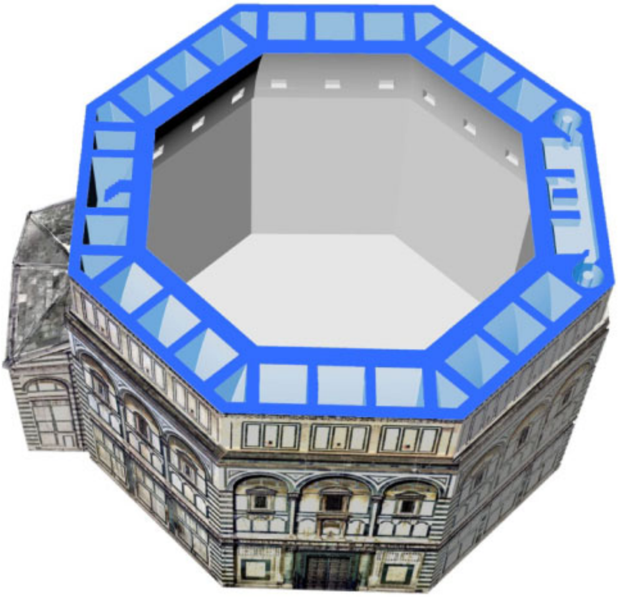

Figure 9. The box structure of the dome at attic level (by Giorgi & Matracchi 2017).

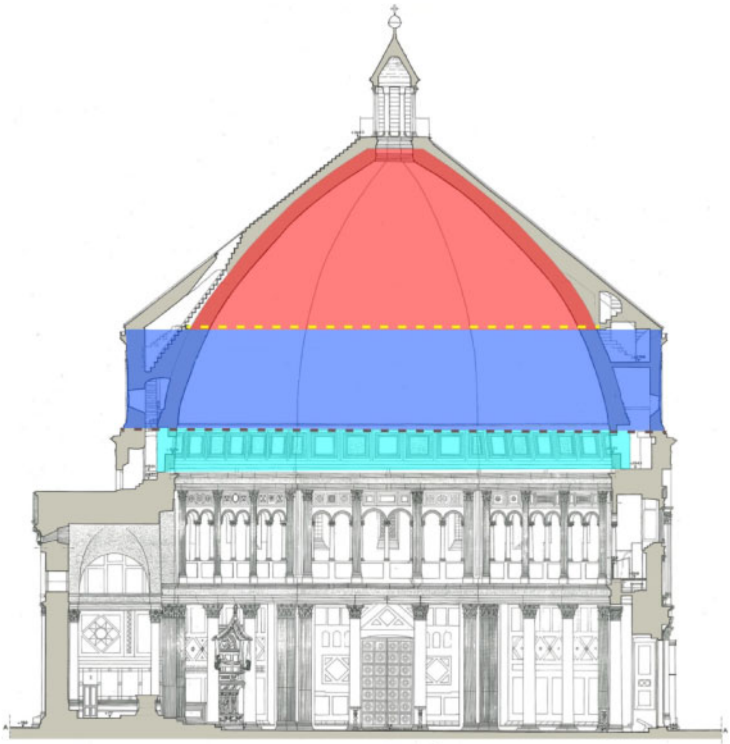

Figure 10. In the dome section the following are highlighted: the first section with horizontal rows (cyan), the box structure part, the final section in brick (red); the wooden tie (yellow dotted line) and the metal tie added in 1514 (brown dotted line) are also indicated (basic drawing Giovannini 1996).

Where the box structure ends, the dome continues with the use of bricks, for the most part salvaged material most likely obtained from the dismantling of the Roman walls of Florence (Giorgi & Matracchi 2017, p. 205). In the transition from the box structure to the single shell structure, a wooden tie is placed along the extrados of the pavilion crossing the transversal partition walls (Figure 11). The original connections visible between the wooden elements show tooth connections with the use of wooden nails. The tests of the state of tension of the wooden tie revealed a modest amount of tensile strength (Negri et al. 2017); the brick dome, with its springer on the inclined row of the stone one, transmits the thrust mainly to the box structure of the stone dome.

Figure 11. The wooden ties intersect at the corners of the octagonal plan of the Baptistery; the image shows the change in material of the dome at the level of the tie: below the masonry is stone, and above brick.

The construction device of the dome is therefore particularly complex. Considering the vertical rise, the stone part and the brick part are almost the same, but if we take into account the surface of the intrados the former would be clearly larger. In the stone part, there are two highly important aspects. The first is the box structure, which extends for 35% of the vertical rise of the dome; the second is the masonry below the box part, which includes an initial section of the dome constructed entirely of horizontal rows and interrupted both by the openings facing onto the inside of the baptistery, and the passages between the compartments of the garret. In view of this construction aspect, the position of the wooden tie at the base of the brick dome formed of a single shell appears justified.

The identification of the box structure profoundly changes how we consider the construction concept of the dome of the Baptistery, which until recently was considered to be a pavilion reinforced by transversal bearing walls, and allows us to understand more fully the position and extent of the system of cracks that has formed.

The dome has limited and essentially stable cracks; this is also due to the metal tie added in 1514 in the wall offset at the base of the attic level (Blasi et al. 2017, pp. 124–125). This tie is highly effective given that it is positioned at the base of the box structure. Moderate traces of cracks have been found in the corners of the intrados of the dome, up to 1-2 cm wide, which are barely visible in the mosaics where they are hidden by plaster, and more evident in the band of the medallions of the saints close to the springer of the dome, where deviations can be observed between the slabs of the stone cladding (Blasi et al. 2017, p. 120).

The masonry masses of the structure below the dome reduce a great deal on the inner sides of the Baptistery, where there are columns on the ground floor and mullion windows on the matroneum level. It should be noted that the partition walls of the garret are at times strongly misaligned with those of the matroneum, as on the north side. It is no surprise that these construction features together have resulted in the largest cracks in the matroneum area (Figure 12).

More extensive cracks have been observed in particular in the sides of the entrance door (up to 4–5 cm wide). On the inner side of north wall of the matroneum there is a highly visible vertical crack, which has been repaired with brick fragments and extends to the barrel vault above and the wall abutting the mullion window. The small column of the mullion window itself in turn generates a crack in the lintel below supported by columns (Giovannini 1996). On the outer sides clad in marble the cracks have been repaired by inserting marble plugs which restore the continuity of the horizontal cornices (Blasi et al. 2017, pp. 121–122).

The first pioneering modelling of the dome of the baptistery with the calculation of the elements dates back to the mid 1990s (Blasi & Papi, 1996). The topic was addressed there after several times with increasingly refined numerical mode salso thanks to the recentavailability of an accurate laser scanner survey (Bartoli et al. 2017). It would be very interesting and appropriate to further characterise the behaviour of the dome with modelling that takes into account the box structure of the dome. It would be just as useful to check the possible effects caused by the vertical misalignment of the partition walls, considering in particular the displacements between the transversal bearing walls of the box part of the dome and those below of the matroneum.

Figure 12. Detail of the outer wall of the north side of the attic; the obvious repaired crack is shown (in red) (by Giovannini 1996).

3 SHARED CHARACTERISTICS OF THE BAPTISTERY DOME AND BRUNELLESCHI'S DOME

For Brunelleschi, the Baptistery dome was an object to study and consider in order to develop construction solutions for the much larger dome of Santa Maria del Fiore. Several construction solutions shared by the two buildings have been observed, such as the use of stone in the lower part and then continuing with brick; the wooden tie revived with anchoring in the ribs; the use of two intermediate ribs in each web of the pavilion. Moreover, the roof partly resting on the rampant vaults of the baptistery could have suggested the creation of a double shell dome (Rocchi Coopmans de Yoldy 1996b).

Leaving aside the many and complex aspects linked to the brick masonry structure of Brunelleschi's dome, the strengthening of the connection between corner ribs and intermediate ribs by means of sub-horizontal arches is a significant innovation (Figures 13,14). The corresponding portion of the external ribbed dome is also strengthened by these sub-horizontal arches. To make the cohesion between such elements more effective, the sub-horizontal arches are made up of a segmental arch in vertical bricks to support the bricks arranged in a homogeneous position to that of the bricks of the ribs and of the external dome (Giorgi & Matracchi 2018). It still needs to be ascertained whether the solution of the sub-horizontal arches with variable sections (larger on the corner ribs side) also arises from the need to conceal the metal ties positioned in the external area of the ribs; indeed, a 24-sided polygonal tie could have had sections transversal to the corner ribs arranged partly inside the sub-horizontal arches (Figure 15). In any case, the corner areas of the pavilion of the dome of Santa Maria del Fiore are a clear construction innovation which creates a unitary system consisting of corner ribs, intermediate ribs and sub-horizontal arches (Rocchi Coopmans de Yoldy 2006).

However, perhaps the most significant constructive aspect that Brunelleschi could have taken from the dome of the Baptistery lies behind all of this. Reference is made to the box structure of the stone part, which Brunelleschi reworked with a double dome, intermediate ribs and stiffening arches close to the corners that reinforce the connection between adjacent ribs and at the same time innervate the external dome (0.80 m thick) which is much thinner than the internal one (about 2 meters thick) (Figure 16).

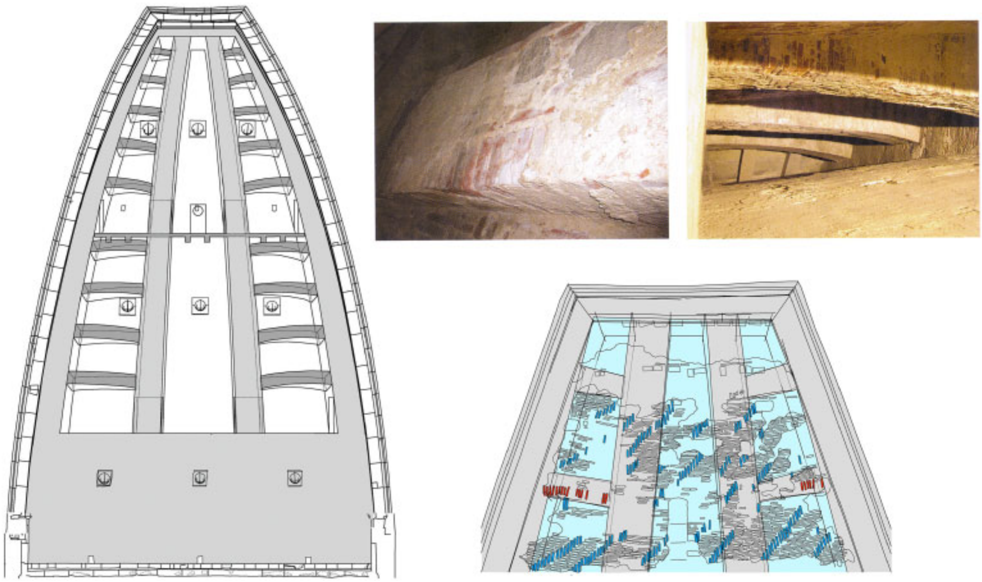

Figure 13. N-NE web of the dome of Santa Maria del Fiore highlighting the ribs and corbel-arches; (left), survey of the masonry structure of the NE outer dome highlighting the bricks (in red) of the corbel-arches placed vertically; (top right) details of corbel-arches with vertical bricks visible in the lower part (by Giorgi & Matracchi 2006).

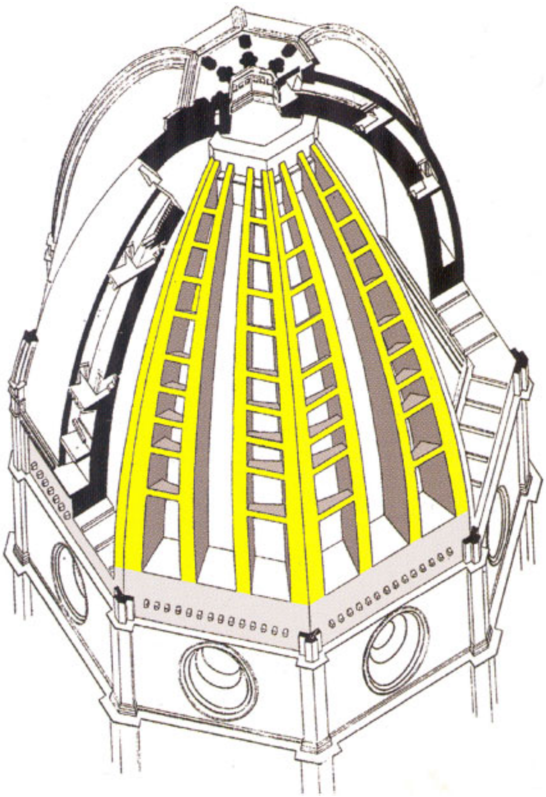

Figure 14. Axonometric diagram of the dome of Santa Maria del Fiore highlighting the connections between the corbel-arches and ribs (by Coompans de Yoldi 2006).

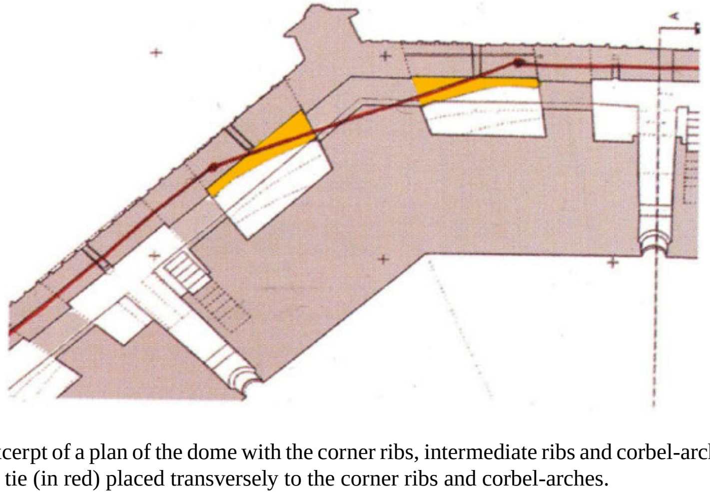

Figure 15. Excerpt of a plan of the dome with the corner ribs, intermediate ribs and corbel-arches (in yellow); hypothesis of a tie (in red) placed transversely to the corner ribs and corbel-arches.

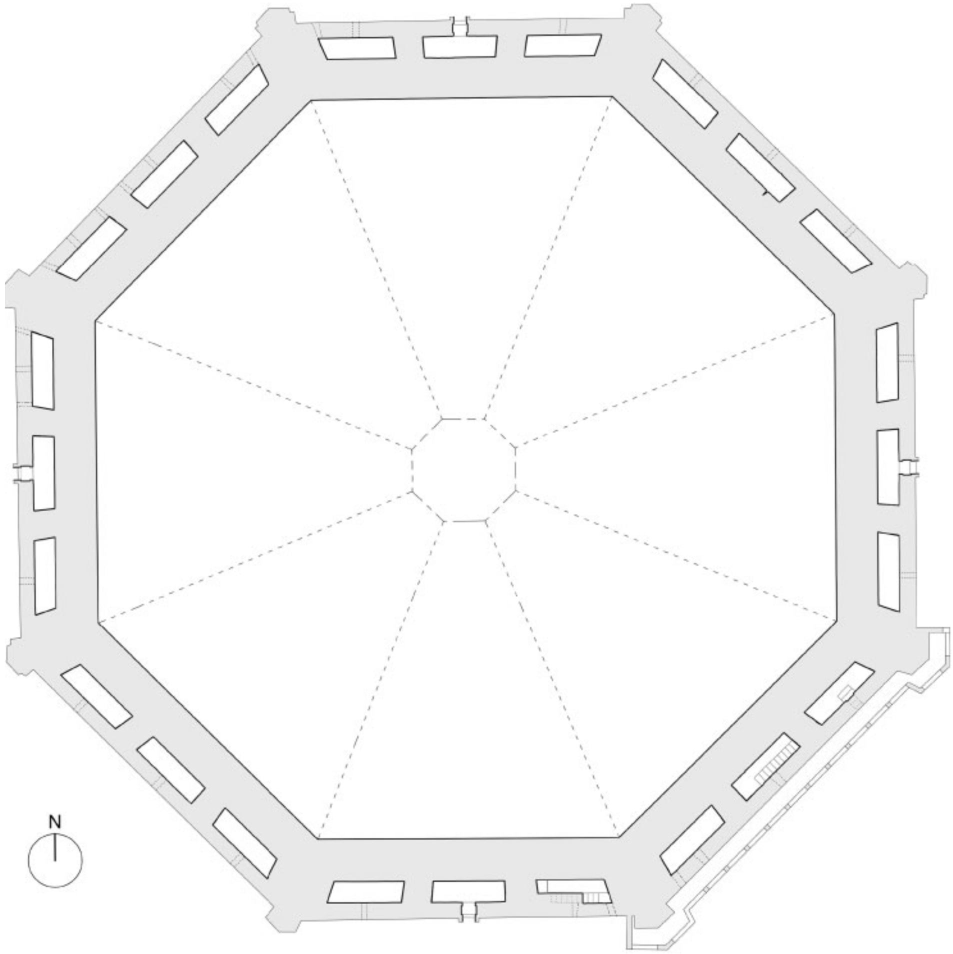

Figure 16. The plan of the Brunelleschi's dome shows the box structure formed by the inner dome, ribs and the outer dome.

4 CONCLUSIONS

The cognitive approach to the buildings should seek to understand their specific features, which are almost never self-evident, without making generalisations, simplifications, or assuming pre-conceived ideas that could place our vision of the construction device far from reality, in a (perhaps refined) metaphysical dimension.

The mere geometric form, even if based on highly detailed surveys, should be considered an indispensable but not exhaustive tool. In order to understand the actual construction elements it is necessary to identify and interpret the construction activities in the context of the construction site practices, or the construction sites that followed one another over time, considering the consequent specific operating methods and the choices made in the production and installation of the materials used. The construction site is a place par excellence of architectural experimentation, where the countless possible options reach executive synthesis. And this is not exempt from rethinking, adaptations and sometimes contradictory choices.

In the case of the Baptistery of Florence, there was no shortage of adaptations on the scarsella side, where the continuity of the octagonal perimeter wall is interrupted. A further vault was therefore added to the scarsella space and, on this same side, a decision was made during the works to close some openings which at the base of the dome would have alternated with mosaics depicting saints. The vertical misalignments between the transversal partition walls on different levels are no less significant, in particular between the mezzanine level and the garret, due to determining architectural choices and the decision to create compartments of a similar width on each side at the base of the dome.

It is customary for an ancient building to be made up of a complex system of construction layouts, which reflect the complexity of the construction history, with conditions of possible local vulnerability. This is made even more complex by the long timeframe of ancient architecture, which introduces further variables as a result of successive transformations, sudden external factors such as earthquakes, or the degradation of the materials themselves.

Knowledge of complex ancient buildings is almost always recognised as a process. This is well exemplified by the identification of the box structure in the stone part of the dome of the Baptistery of Florence, which today provides us with a profoundly different construction concept than the one considered until recently. This finding also has obvious repercussions in the interpretation of Brunelleschi's dome, which in turn is entirely recognised as a box structure with an outer dome innervated by sub-horizontal arches close to the corners of the octagonal pavilion. The recurring interpretation difficulties posed by the construction layouts of the architecture therefore require due caution in making diagnostic interpretations and in the consequent conservation projects, which could be based on reductive or even misleading information.

REFERENCES

Aminti, P. 1996. Rilievo e determinazione della curvature della cupola, analisi sui rapporti dimensionali tra principali elementi strutturali interni, in Giuseppe Rocchi Coopmans de Yoldy (ed.), *S. Maria del Fiore. Piazza, Battistero, Campanile*, Firenze, Il Torchio, p. 104.

Bartoli et al. 2017. Bartoli G., Betti M., Monchetti S., Modellazione numerica ed analisi strutturale del Battistero di San Giovanni a Firenze, in Francesco Gurrieri (ed.) *Il Battistero di San Giovanni. Conoscenza, Diagnostica, Conservazione*, Firenze, Mandragora, pp. 135–157.

Blasi C. & Papi R. 2004. Geometria e struttura, in Giuseppe Rocchi Coopmans de Yoldy (ed.) *S. Maria del Fiore. Piazza, Battistero, Campanile*, Firenze, Il Torchio, pp., 125–127.

Blasi et al. 2017. Blasi C., Ottoni F., Coïsson E., Tedeschi C., Battistero di San Giovanni in Firenze. Note su dissesti, lesioni e catene, in Francesco Gurrieri (ed.) *Il Battistero di San Giovanni. Conoscenza, Diagnostica, Conservazione*, Firenze, Mandragora.

Choisy A. 1899. Histoire de l'architecture, Paris, Gauthier-Villars, T. II, p. 602.

Degl'Innocenti P. 2017. Misurare, disegnare, conoscere: dai rilievi del San Giovanni alle ipotesi storico costruttive, in Francesco Gurrieri (ed.), *Il Battistero di San Giovanni. Conoscenza, Diagnostica, Conservazione*, Firenze, Mandragora, pp. 90, 96.

Durm J. 1887. *Die Domkuppel in Florenz und die Kuppel der Peterskirche in Rom*: *zwei Grossconstructionen der italienischen Renaissance*, Berlin, Ernst & Korn, plate II.

Fondelli, M. 2004. La Cupola di Santa Maria del Fiore. Antiche testimonianze e nuove ricerche sperimentali, in Giuseppe Rocchi Coopmans de Yoldy (ed.), *S. Maria del Fiore e le chiese fiorentine del Duecento e del Trecento nella città delle fabbriche arnolfiane*, Firenze, Alinea Editrice, pp. 343–358.

Giorgi, L. 2004. Il sistema voltato del Battistero, in Giuseppe Rocchi Coopmans de Yoldy (ed.), *S. Maria del Fiore* e *le chiesefiorentine del Duecento e del Trecento nella città delle fabbriche arnolfiane*, Firenze, Alinea Editrice.

Giorgi L. & Matracchi P. 2006. Santa Maria del Fiore, facciata, corpo basilicale, cupola, in Giuseppe Rocchi Coopmans de Yoldi, *S. Maria del Fiore. Teorie e storie dell'archeologia e del restauro nella città delle fabbriche arnolfiane*, Firenze, Alinea Editrice, pp. 316–317.

Giorgi & Matracchi 2017. Le murature a cassone alla base della cupola del battistero e altri aspetti costruttivi, in Francesco Gurrieri (ed.) *Il Battistero di San Giovanni. Conoscenza, Diagnostica, Conservazione*, Firenze, Mandragora.

Giorgi L, & Matracchi P. 2018. I mattoni del Brunelleschi. Osservazioni sulla Cupola di Santa Maria del Fiore, in *Costruire in laterizio*, 2018, 176, pp. 53–61.
Giovannini, P. 1996. L'apparecchio murario e il rivestimento interno del piano terra e del matroneo. Materiali, tecniche di lavorazione e caratteristiche di messa in opera, in Giuseppe Rocchi Coopmans de Yoldy (ed.) *S. Maria del Fiore*. *Piazza, Battistero, Campanile*, Firenze, Il Torchio, pp. 87–89.
Matracchi, P. 1992. *La chiesa di Santa Maria delleGrazie al Calcinaiopresso Cortona e l'opera di Francesco di Giorgio,*Cortona, Calosci, pp. 18–19.
Miceli E. & Riccardo Papi R. 2004. Sulla statica del battistero alla luce delle nuove indagini e delle interpretazioni dei dati sperimentali, in Giuseppe Rocchi Coopmans de Yoldi (ed.) *S. Maria del Fiore e le chiese fiorentine del Duecento e del Trecento nella città delle fabbriche arnolfiane*, Alinea Editrice, Firenze, pp. 177.
Morelli A. 2004. Indagini geofisiche non invasive sulla volta della scarsella del Battistero, in Giuseppe Rocchi Coopmans de Yoldi (ed.) *S. Maria del Fiore e le chiese fiorentine del Duecento e del Trecento nella città delle fabbriche arnolfiane*, Alinea Editrice, Firenze, pp. 167.
Negri et al. 2017. Negri M., Fellin M., Ceccotti A., I legni della cupola del Battistero, in Francesco Gurrieri (ed.) *Il Battistero di San Giovanni*. *Conoscenza*, *Diagnostica*, *Conservazione,* Firenze, Mandragora, pp. 170–173.
Pietramellara C. 1973.*Battistero di S. Giovanni a Firenze*, Firenze, Polistampa, pp. 20–21, 33.
Pisetta, C. & Vitali G. M. 1996. Nuove acquisizioni sul tabernacolo di Andrea Orcagnaattraverso il rilievo interpretativo, in Diane Finiello Zervas (ed.), *Orsanmichele a Firenze*, Modena, Franco Cosimo Panini, p. 382.
Rocchi Coopmans de Yoldy, G. 1996a. Il Battistero di San Giovanni. Lo svolgimento della fabbrica, in Giuseppe Rocchi Coopmans de Yoldy (ed.) *S. Maria del Fiore*. *Piazza*, *Battistero*, *Campanile*, Firenze, Il Torchio, pp. 43, 47–48.
Rocchi Coopmans de Yoldy G. 1996b. Brunelleschi e il Battistero, in Giuseppe Rocchi Coopmans de Yoldy (ed.) *S. Maria del Fiore*. *Piazza*, *Battistero*, *Campanile*, Firenze, Il Torchio, pp. 64–65.
Rocchi Coopmans de Yoldy G. 2006. Il cantiere del complesso di Santa Maria del Fiore dall'epoca arnolfiano-giottesca a quella brunelleschiana, in Giuseppe Rocchi Coopmans de Yoldi (ed.)*S. Maria del Fiore e le chiese fiorentine del Duecento e del Trecento nella città delle fabbriche arnolfiane*, Alinea Editrice, Firenze, p. 265.
Trattati di architettura 1967. *Trattati di architettura, ingegneria e arte militare*/Francesco di Giorgio Martini, Corrado Maltese (ed.), Livia Maltese Degrassi (tr.), Milano, Edizioni il Polifilo, T. I, p. 92.