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Medieval transformations of the Basilica of St Anthony in Padua based on an analysis of the original brickwork

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ABSTRACT: The imposing appearance of the Basilica of St Anthony in Padua (Italy) results from several major transformations carried out after an initial construction phase between the 1230s and 1260s. Due to the lack of medieval building archives, the successive forms of the pilgrimage landmark remain uncertain. Based on a recent survey of the church and a detailed analysis of its original brickwork, this contribution provides a fresh set of evidence casting light on the early appearance of the Basilica as intended by its 13th-century builders. The results pave the way for an unequivocal dating of the building, together with a finer understanding of medieval building techniques in Northern Italy.

1 INTRODUCTION

1.1 Brief history of the Basilica

The oldest document related to the Basilica of St Anthony attests to an active construction site on the outskirts of Padua in 1238, seven years after the death of the Portuguese-born Franciscan friar (Lisbon, 1195–Padua, 1231). Although the laying of the first bricks can hereby be situated between this date and the Saint’s swift canonization in 1232, little is known about the next 150 years, which saw the erection of the church. Indeed, only a tiny handful of construction-related documents have survived the passage of time.

The early history of the massive brick Basilica and its wooden domes is thus only sketched from secondary sources such as municipal funds, religious celebrations, donations or indulgences. Based on these documents, a widely accepted chain of events has emerged in recent literature (Baggio & Bertazzo 2012; Heinemann 2012), as summarized in Table 1. Additionally, two rare city reliefs on tombs dated 1329 and 1345 show that the Basilica was already covered by several domes in the first half of the 14th century (Hein 2012). More precise events can be traced from the 1390s onwards, starting with the unfortunate collapse of a campanile tower in 1394. The last major intervention consisted in the decorative painting of the interior, following a renovation campaign carried out by architect Camillo Boito around 1895 for the 7th centenary of St Anthony’s birth.

1.2 State of research

The large body of art history research on the sequence of the Basilica’s construction was initiated in the mid-19th century with the monograph by Gonzati (1852).

Table 1. Main historical events.

1232–38	Start of the construction.
1237–56	Occupation of Padua by Ezzelino da Romano.
1256–63	Papal indulgences to finance the construction.
1263	First translation of the relics to the new church.
1265	Municipal financing.
1267–95	Construction of radial chapels.
1307	Municipal financing.
1310	Second translation after <i>varia et immensa mutatio</i>
1350	Third and last translation to the current tomb.
1382	Construction of the Chapel of Luca Belludi.
1394	Collapse of a campanile tower, followed by municipal financing and papal indulgences.
1690–1745	Construction of the Chapel of the Relics.
1749	Fire destroying four timber domes.

Several hypotheses were formulated over the following decades, notably the postulate of a previous two-level ambulatory – like that of Notre-Dame in Paris – (Delling 1975) or a first single-nave church on the model of the Basilica of St Francis in Assisi (Salvatori 1981). Although the single-nave theory has been discredited in recent research, there are still different views on the aspect of the Basilica around the turn of the 14th century. For example, Valenzano (2012) considers that the church was covered by six domes as early as 1263, when the relics were moved to the western transept. The next translation in 1310 – probably to the last chapel of the ambulatory – would correspond to a convenient relocation to the newly built eastern part. On the other hand, Heinemann (2012) comes to the conclusion that the translation of 1310 was motivated by the start of the vaulting above the crossing area, until then protected by provisional roofs.



Figure 1. Basilica of St Anthony, north-western view (photo: author).



Figure 2. Basilica of St Anthony, south-eastern view (photo: author).

As can be seen, key questions remain open after almost two centuries of art history research. The remaining mysteries mostly surround the form of the church before the junction with the eastern transept, the dating of the domes and the scale of damage caused by the collapse of a tower. In the absence of further onsite surveys and absolute dating, none of the current hypotheses prevails undisputed, as reflected in the latest major publication on the Franciscan Basilica (Ruzza 2016).

1.3 Scope of investigations

In 2019, the Institute of Construction History and Preservation (IDB, ETH Zurich) launched a research project under the direction of Professor Stefan M. Holzer, in collaboration with the *Veneranda Arca di Sant'Antonio* and financed by the Swiss National Science Foundation (SNSF). Drawing on existing research, the project aims to establish a coherent timeline for the construction of the Basilica of St Anthony using state-of-the-art building archaeology methods (laser scanning, photogrammetry and thermal imagery) as well as absolute dating techniques (dendrochronology and ^{14}C).

After one and a half year of investigations, this paper provides a first set of results casting light on the construction techniques, the architectural influences

and the dating of the Basilica. It focuses particularly on one key question; namely, the early appearance of the church as intended by its 13th-century builders. The outcomes are based on an in-depth survey of the Basilica, including all walled-in corridors, and an early attempt to sort its original brickwork using mensiochronology (i.e. dating of bricks based on dimensions and patterns). Preliminary results from dendrochronological dating of the domes are included in this paper, although further discussed by Diaz *et al.* in this same volume. Finally, ongoing research steps and hoped-for results are briefly presented at the end of the paper.

2 CONSTRUCTIVE FEATURES

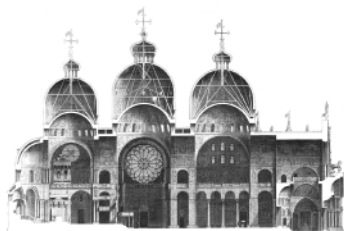
2.1 Western part

In the oldest part of the church initiated in the 1230s (Figure 1), the bearing structure consists of large brick pillars (about 4×4 m) supporting 3-metre-thick semi-circular arches spanning about 13.5 m. The exterior walls are formed of thinner brick infills (73–96 cm) inserted below the arches. The nave and the transept are covered by five masonry domes of similar diameters (14.40–14.48 m) and thicknesses (32–43 cm); the higher dome on top of the crossing is slightly smaller (14.30 m). On top of these brick shells, lightweight timber structures elevate the silhouette of the church with four domes and a truncated cone under which the relics were placed in 1263. The thrust forces of the arches are taken up by several buttresses positioned on the lateral sides of the Basilica, some of them integrated into the façade or transept walls.

This structure inevitably echoes the shining example of the Basilica of St Mark in nearby Venice, raised two centuries earlier in the competing lagoon city. Following a Greek-cross plan, St Mark's is, in turn, considered to be inspired by oriental models such as the Church of the Holy Apostles (4th century) or Hagia Sofia (6th century). Despite the different plans and slightly larger proportions in Padua, the structural similarities between St Mark's and the western part of St Anthony's are striking (Figure 3). However, the domes of St Anthony's rest on higher drums, while the profile of the masonry shells is ogival rather than semi-circular. Knowing the competitive climate between the two cities, one might reasonably wonder whether these soaring domes were not part of a symbolic race in the flat coastal landscape. Indeed, the original timber roofs of St Mark's – completely destroyed by fire in 1419 but still visible in mosaics – were only added on the masonry shells between the second quarter of the 13th century and ca. 1270 (Piana 2019).

Preliminary results from dendrochronological dating of the domes of St Anthony (samples analysed by the Laboratory Dendrodata in Verona) indicate that three of the cupolas (façade, intermediate and *arca*) are still largely original from the early 1280s (Pignatelli unpubl.). These structures, which miraculously survived fire and moisture for more than

St Mark, Venice



St Anthony, Padua

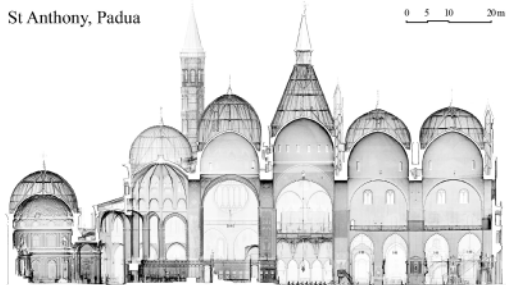


Figure 3. Longitudinal sections of St Mark's and St Anthony's at the same scale (drawings: Visentini 1761; author).

seven centuries, might thus be the oldest timber domes preserved in Europe. The larch trees cut in the 1280s position the construction of these timber structures to shortly after those of St Mark's. As the Basilica of St Anthony would have been higher even just with masonry domes, did the Venetian authorities attempt to raise their landmark in reaction? Could the timber domes of St Anthony be the result of another outbidding? These questions might soon be answered after a second sampling campaign.

A particular feature of the western side of the Basilica lies in the intricate network of corridors meandering inside arches and buttresses. Giving access to every attic and external roof, this "*intricato Laberinto*" (*sic*) already dazzled 16th-century observers (Polidoro 1590). As noticed by Valenzano (2012), walled-in passages are common in Romanesque churches of Lombardy, but no other building exhibits such a complex network. Thanks to recent developments in laser scanning technology, the until now neglected galleries could be surveyed with great precision in the scope of the current investigations (Figure 4). These untouched passages provide fresh evidence about the original appearance of the Basilica which will be discussed in the next section.

2.2 Eastern part

This part of the church was likely built between the late 1260s – marked by the laying of the foundation stone of a radial chapel – and 1310, date of the second translation of the relics to the new part of the church (Table 1). The timber domes and attics of this zone were destroyed by fire in 1749. An unusual secondary transept, covered by a dome and two cross vaults, is connected to the older part of the church at the centre of the western transept's gables (Figure 2). In this area,

a construction joint is clearly visible between the two transepts at the level of the balustrades, highlighting two different building phases. The diameter of the dome overhanging the presbytery (13.95 m) is noticeably smaller than the western ones (14.30–14.48 m), although its thickness (37–39 cm) is comparable to the others (32–43 cm). On the north side, the transept is flanked by the Chapel of the Madonna Mora, usually considered – and this hypothesis is seriously challenged by ongoing analyses – as the remaining part of an older Church of Mary.

Beyond the two campanile towers, the choir is covered by a 15-part vault on top of which stands another timber dome dated by archives to 1424. The structure of this choir surrounded by an ambulatory with radial chapels is likely inspired by French Gothic churches such as Notre-Dame in Paris or the Cathedral of Chartres. A closer source of inspiration might have been provided by the Basilica of St Francis in Bologna (1236–1263), an early example of Italian Gothic. Based on those dates and the architectural similarities, Heinemann (2012) does not exclude a transfer of builders from Bologna to Padua.

The tower collapse of 1394 inevitably damaged the choir area, yet the extent of the ensuing reconstruction is still unclear. Dellwing (1975) suggested that the choir and the ambulatory were torn down and largely rebuilt. He supported the hypothesis of a previous two-level ambulatory, from the observation that the bases of the towers exhibit arches bearing traces of an open gallery. In another vein, Bresciani Alvarez (1981) suggested that the previous ambulatory's vaulting reached the same level as the radial chapels, like in St Francis's in Bologna. However, a close examination of the masonries does not reveal traces of major modifications of the current ambulatory. Moreover, such arches do not necessarily correspond to an opening: they could also enable a load transfer from the tower to the underlying pillars. Similar arches may for example be observed on the tower of the church of St Francis in Udine (1260–1266). At the current stage of the investigations, it seems that the reconstruction was rather limited to the vaulting of the choir.

Lastly, the Chapel of the Relics was built in the first half of the 18th century where stood the fifth radial chapel, providing the Basilica with a final dome. Interestingly, its timber roof structure and those rebuilt after the fire of 1749 do not differ greatly from the medieval models. Compared to the more elaborate details applied in the neighbouring church of Santa Giustina in the early 17th century, the timber structures of St Anthony mostly rely on simple lap joints fastened by large iron nails.

3 L'INTRICATO LABIRINTO

3.1 A rational network

The upper corridors running through the arches and buttresses of the western part of the Basilica connect the attics of the domes to the side aisles, to the

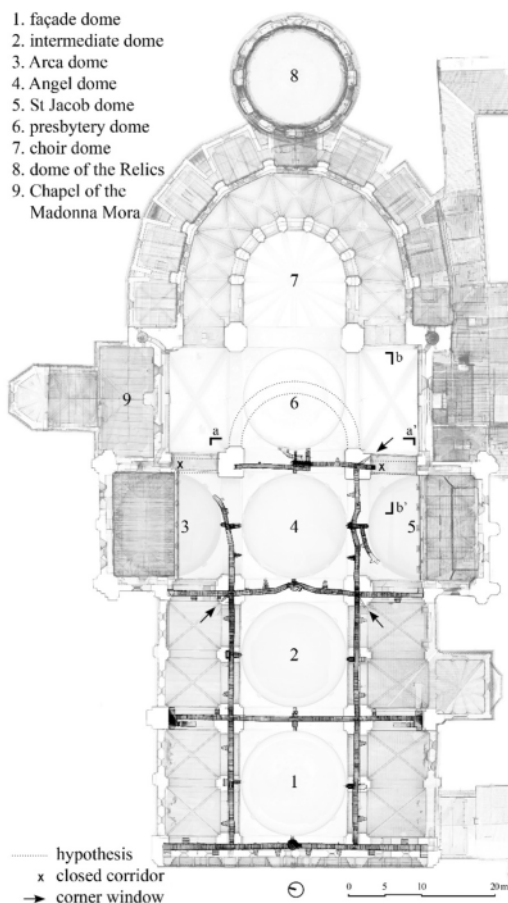


Figure 4. Basilica of St Anthony, plan of the intermediate attics and the upper corridors (drawing: author).

balustrades of the western transept (obsolete after the construction of two chapels) and to the upper gallery of the façade (Figure 4). Another corridor is situated a few metres below in the front façade to access a lower gallery and, via a small staircase, the cloister on the south-western corner of the church.

Once precisely surveyed, this network appears much more rational than the confusing labyrinth experienced onsite and presented as such in literature. A first observation of these 60–90 cm wide corridors reveals a remarkable continuity between the arches and the buttresses, hence disqualifying the possibility of a single-nave predecessor. To bring light into these dark and steep passages, medieval masons opened a series of tiny windows, the position of which is a key to understanding the original plans. Indeed, around the façade and intermediate domes, the longitudinal corridors are illuminated from the outside by two lower windows and a central upper one, positioned just below the Lombard band (Figures 1–4). On the opposite side of each gallery, a small central window opens towards the inner side of the domes, lit by four larger windows placed above each pendentive. The situation is

different around the Angel dome, where there are no lateral light sources. However, as the upper part of this dome features no less than 18 windows (Figure 3), light was brought into the corridors from the inner side by simply switching the direction of the lower openings towards the interior. Moreover, the perilous crossings between perpendicular staircases at the junction between the nave and the transept are illuminated by dedicated corner windows (Figure 4).

The implacable logic behind this original network of passages in symbiosis with the system of arches and buttresses – as their wisely arranged openings – supports the idea of an earlier T-shaped basilica crowned by five domes (the tau cross, associated with St Anthony of Egypt and later adopted by St Francis of Assisi, would have drawn a clear distinction from the Basilica of St Mark). Hence, these observations reinforce the hypothesis that the domes were planned from the start of the construction. The theory that the masonry shells were already in place for the translation of 1263 is not impossible, though still uncertain at this stage.

As previously discussed, the connection between the two transepts marks different building phases, separated by a visible joint at the level of the balustrades. In light of the rational arrangement of corridors, the easternmost passage is revealed to be of utmost importance to picture the appearance of the Basilica before the addition of its eastern part. This corridor is abruptly interrupted on its southern end by an open arch in the transept's wall. Only a one-layer brick wall prevents the drop from the corridor into the transept. A similar interruption can be observed at a lower level in the northern arm of the transept, where a corridor used to connect the balustrade to the ground floor, thereby closing the circuit. These interruptions, together with the unusual profile of the pillars, indicate exactly where the previous wall of the transept stood.

Furthermore, a series of bricked-up openings following the logic described above has been recorded on the eastern side of the upper corridor (Figures 5 and 6).

Thanks to the accuracy of the digital survey, their positioning within the overall brickwork can be appreciated for the first time. Firstly, a corner window similar to those on the opposite side of the transept shows that the original construction continued further to the east. Its perfect alignment with the lower support indicates that the latter likely once formed an exterior corner pilaster. Secondly, a few steps higher, a lateral window provided additional light to this corridor. Above the centre of the arch and perfectly aligned with the previous opening, a final window confirms that an external wall stood here. Since there are no openings on the opposite wall, builders clearly counted on this side to illuminate the passage. Thirdly, between these two windows, a door seemingly provided access to a roof, connected to the body of the church between these three openings and the lower arch. On the left side of this door, inside of the construction joint, a blind arcade of the typical Lombard band type can be

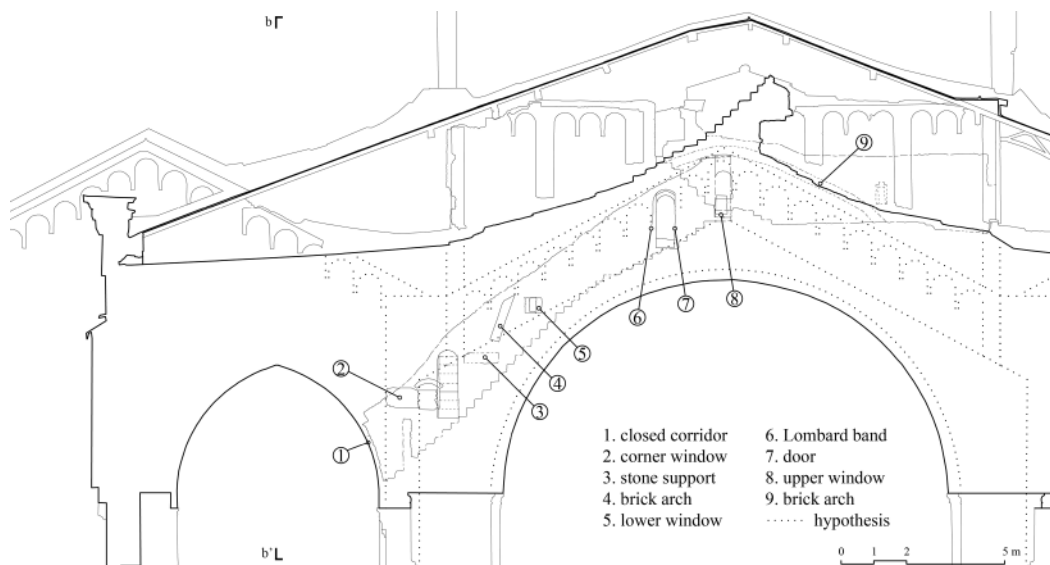


Figure 5. Basilica of St Anthony, transversal section a-a', looking west (drawing: author).

observed. This important hint provides further proof of an exterior wall, and also a means to position the rest of the arcade. Moreover, the first steps of a spiral staircase are visible at the level of the ridge, suggesting the presence – or at least the planning – of a third small tower on the eastern side of the Angel dome. Both the radius and the shape of the stone steps indicate that it was similar to the two central towers on the west.

A last noteworthy observation concerns the western side of this corridor, where a brick arch corresponding to the higher pendentives of the Angel dome can be seen in two places. Shortly below the landing of this arch, a large stone was inserted into the masonry to diffuse the load. These structural features contemporary to the rest of the lower masonry confirm that a higher dome above the crossing was planned well ahead but not raised subsequently.

3.2 Hypothetical plan

The analysis of the brickwork tends to indicate that the original plan consisted in a T-shaped basilica covered by five domes: two above the nave, one above each transept arm and a higher one on the crossing. Furthermore, the openings in the eastern gable suggest that the plan likely ended with a semi-circular apse covered not by a full dome, but rather by a simple roof. This apse was probably similar to the one of the Basilica of St Mark in Venice (Figure 3) and covered by a half masonry dome. This common architectural feature can be observed not only in St Mark's but also in other nearby Romanesque churches such as Santa Sofia in Padua, the Cathedral of Verona or the Cathedral of Modena. Beyond a hypothetical silhouette proposed here, the precise appearance of this apse is still, and will certainly remain, undefined.

Yet a ground-penetrating radar survey might provide valuable insights into its original floor plan.

At this point, a more precise picture of the *varia et immensa mutatio* recorded around 1310 emerges: it could refer to the piercing of the first transept walls and the demolition of the apse, as final steps of the enlargement works started around 1265 with the construction of radial chapels. The municipal financing of 1307 would have thus helped accelerate the final junction between the two parts of the church. From a structural point of view, it cannot be ruled out that, after the completion of the new choir and campanile towers, the eastern transept was erected around the existing apse, a sequence which would have encroached less on liturgical activities. This practical way of proceeding would also explain the very unusual presence of this transitional space now referred to as a second transept.

4 BRICKWORK

4.1 Mensiochronological analysis

The above investigation has provided a first set of evidence leading towards an original T-shaped plan. This hypothesis can now be contrasted with a preliminary analysis of different brickworks applied in various parts of the building. The dating of bricks based on the evolution of their dimensions and arrangements was progressively established in Italy with the works of Kleinbauer (1968), Mannoni (1984), Pittaluga and Quirós Castillo (1997), Varosio (2001), Causarano (2017) and others. In Padua, a mensiochronological curve was drawn by Scillia (2011) based on the survey of 11 buildings (40 to 50 bricks per case study). According to this study, the dimensions (height × width × length) averaged 5 × 12 × 27 cm in

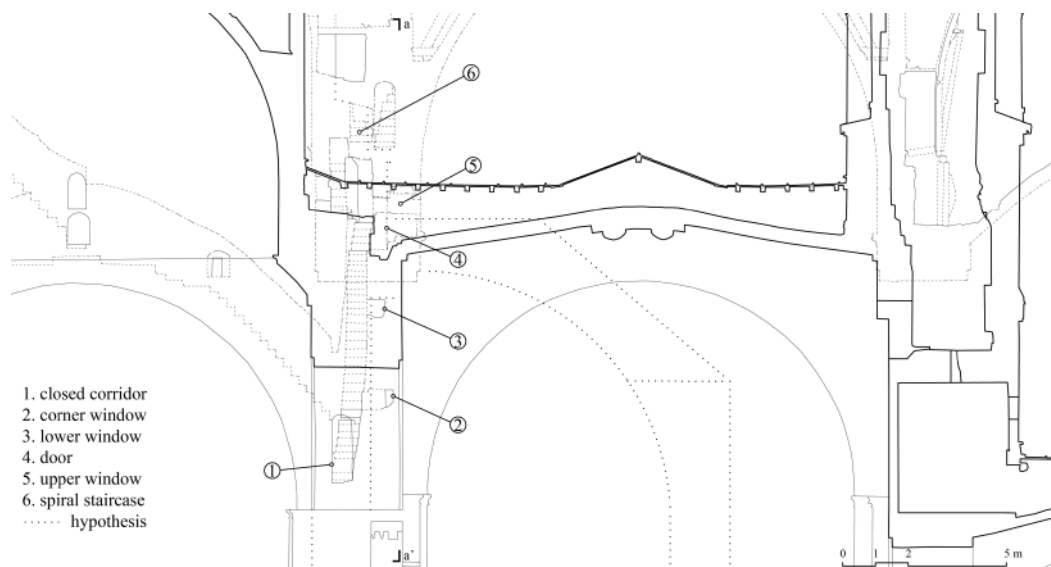


Figure 6. Basilica of St Anthony, longitudinal section b-b', looking north (drawing: author).

the 14th century and had increased by about 2 cm in all directions by the end of the 15th century. Unfortunately, the start of the curve is flawed by an erroneous dating of the Chapel of Luca Belludi (1382), making further comparisons delicate.

In the scope of the present study, a first analysis of brickworks was performed on 10 homogeneous parts of the Basilica: on the exterior drums of the domes, on the eastern transept and on the lower part of the southern tower. As a first step, sample areas including about 200 to 300 bricks were redrawn on the high-density point cloud with a precision estimated to 3 mm. Each wall was surveyed on two separate positions to exclude local repairs and anomalies; only one sample is presented here for the sake of clarity. The resulting frequency distribution of brick dimensions can be represented by two curves (vertical and horizontal measurements) peaking three times: these turning points provide the height, width and length used to characterize brick formats (Figure 7). Each brick pattern can be further described by its module, defined here as the median height of five bricks and four mortar joints. Clearly defined bond patterns do not emerge at the current scale of the survey, except on the 18th-century Chapel of the Relics where layers of headers alternate with layers of stretchers.

The resulting overview reveals a remarkable stability of formats from one side of the Basilica to the other. Even the bricks of the Chapel of the Relics fit within a close range of sizes of $4.7\text{--}5.4 \times 11.2\text{--}12.2 \times 25\text{--}26.7$ cm. This result, which obliterates a dating based on the sole record of brick dimensions, can likely be explained by the financing and ensuing surveillance of the construction site by civil authorities from 1265 onwards. Municipal statutes already referred to standard formats in 1236 and 1277. That second year, an official model for brick moulds (still

visible on a corner of the Palazzo della Ragione) was enforced in the furnaces firing the bricks of the Basilica (Heinemann 2012).

Beyond this apparent uniformity, the distribution of sizes reveals a second level of information: whether masons mostly used entire bricks (steep peaks) or smaller fragments (flat peaks). From this point of view, the dome of the presbytery shows a much higher proportion of intermediate formats. Moreover, the module of this drum is higher than in any other surveyed part of the church: it averages 28.8 cm and, locally, up to 35.1 cm. Hence, this set of evidence tends to allocate the dome of the presbytery to another building phase which seemingly made a more extensive use of salvaged bricks. A last observation concerns the proportion between headers and stretchers. In the western part of the Basilica (from the façade to the *Arca* dome), the proportion of headers exceeds half the number of stretchers. In contrast, the number of stretchers is much higher on the walls forming the eastern part of the building (from the presbytery dome to Chapel of Relics). On the latter chapel, stretchers are even more numerous than headers.

The outcomes of this mensiochronological analysis are thus perfectly in line with the previous hypothesis. At this stage, one can indeed confirm that the masonry of the presbytery dome differs from those on the western side, not only in terms of overall diameter as previously discussed, but also in terms of modules and proportion between headers and stretchers. This last parameter can also contribute to delineating the Basilica in two distinctive parts. However, these preliminary conclusions still have to be contrasted with a broader analysis of brickwork on the entire church, covering much larger sample areas. To this end, automated tracing techniques based on photogrammetric surveys will be applied to entire façades, using recent

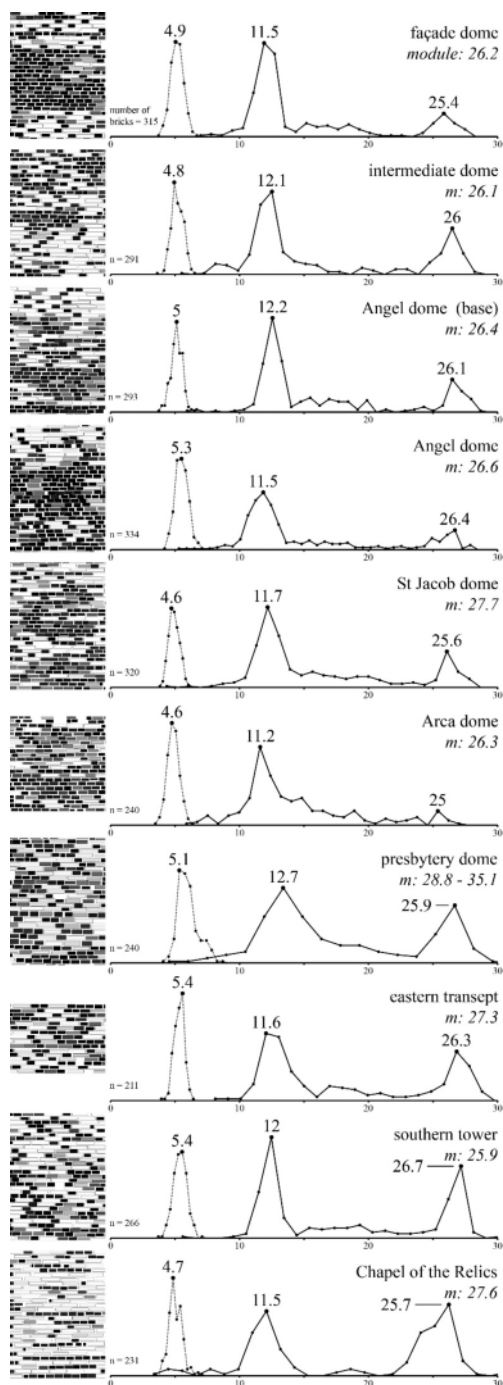


Figure 7. Distribution of brick dimensions (height, width, length) in different parts of the Basilica of St Anthony. Module = 5 bricks + 4 joints. All dimensions in cm.

tools developed at ETH Zurich (IDB) (Potgeter in press). Finally, the erection techniques of the plastered dome shells are currently being investigated based on thermal imagery. For example, detected traces of

timber centerings might provide yet another key for establishing a chronology.

5 FURTHER STEPS

Beyond deepening the survey of the original brickwork discussed in this paper, simultaneous investigations focus on the absolute dating of different parts of the Basilica. A second campaign of dendrochronological analyses should irrevocably date the erection of the western domes untouched by the fire of 1749. Moreover, original boards of spruce used for the vaulting of the corridors are currently being analysed in the hope of dating the construction of the walls in which they are embedded. Due to the lack of dendrochronological curves for spruce in 13th-century Veneto and Trentino, those could not be dated in a straightforward way with this technique. Samples will thus be collected for radiocarbon dating at the Laboratory for Ion Beam Physics (ETH Zurich).

Such ^{14}C analyses will also be applied to mortar samples collected from all over the church. Since organic material has already been detected in the mortar, one can hope for a successful dating of the lower brick structures of the Basilica. Moreover, the chemical composition of these mortar samples will be determined, which could offer an additional key to reading the construction sequences.

Finally, numerous testimonies of medieval building techniques (e.g. tool traces, stonecutter's marks, scratches on bricks, inscriptions, transport marks or traces of scaffoldings) are systematically being recorded. Contrasting these observations with current hypotheses based on accurate onsite surveys and absolute dating could portray a very detailed picture of the successive construction sites and the evolution of building techniques from the 13th to the 18th century. A three-dimensional model of the church is currently being prepared to visualize these findings and test various scenarios.

6 CONCLUSION

The Basilica of St Anthony begins to reveal its secrets. Driven by advanced surveying methods and absolute dating techniques, the present research provides fresh insights into the construction techniques, the architectural influences and the dating of the emblematic brick church.

The analysis of the original brickwork puts forth an original T-shaped basilica generally inspired by the model of St Mark's, featuring five domes and a semi-circular apse. As proposed in the present paper, this apse was likely demolished around the turn of the 14th century to make place for an eastern part started in the mid-1260s.

These preliminary results obtained in a relatively short time confirm the soundness of the approach and place the answers to the next key questions within

reach, namely the dating of the domes (masonry and timber) and the remodelling of the eastern part after the collapse of a tower. In this perspective, the present study paves the way for an unequivocal dating of this major pilgrimage landmark, together with a finer understanding of medieval building techniques in Northern Italy.

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