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The Transmission of the Technology for Gothic Masonry Vaulting to Greece, in the Case of Saint Sophia in Andravida, Elis

Dimitris THEODOSSOPOULOS*[1], Christianna VELOUDAKİ[2]

[1]*University of Edinburgh, School of Architecture and Landscape Architecture, Department of Architecture, Edinburgh, UK*
[2]*University of Edinburgh, School of History, Classics and Archaeology, Department of Archaeology, Edinburgh, UK*

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ABSTRACT

The church of Saint Sophia in Andravida, built around the mid-13th century in Elis, Western Greece has its still-remaining apse roofed in ribbed cross vaults. Built by the Frankish Princes of Achaia who occupied in the 13th and 14th century an area dominated by the native Byzantine architecture, Saint Sophia shows the great effort and attention paid in transferring new architectural forms and technology into a politically and culturally alien environment. This paper discusses the vaults' construction and structural behaviour and explores questions around the technology transfer mechanisms from Western workshops. Although efficient, the vaults appear rather basic, and conservative compared to the contemporary endeavour to gradual disintegrate the envelope in Gothic architecture in Western Europe. On the whole, the analysis of the geometry, construction and structural performance showed a well-executed design with direct local input only at the construction stage.

1. INTRODUCTION

Following the fall of Constantinople in 1204 the lands of the Byzantine Empire were divided between the Crusader leaders who founded there several new states, a period known also as *Frankokratia.* The Principality of Achaia (or Morea) in the Peloponnese, led by Geoffrey I Villehardouin was the strongest and one of the most long-standing among them, lasting until 1430. To establish the new order and support the needs of the new settlers, the Villehardouin Princes created a few significant buildings in their newfound kingdom which included military infrastructure (like their stronghold in Chlemoutsi (*Claremont*) castle or the early phase of Mystras), but also several Catholic churches, abbeys, and other charitable foundations (e.g., hospitals). In an area dominated by the native Byzantine architecture, the patrons launched a construction programme that imported western designs and building techniques. Gothic elements and forms were thus applied in an alien domain to the movement, conditioned by local masons and material resources (Ousterhout 2010, p 262).

Although this period has been seen traditionally in Greece as a foreign, hostile occupation, recent research has demonstrated the existence of cross-cultural relations and exchanges in various aspects of everyday life, art, architecture, and even religious practices (e.g., Gerstel 2001, p 263; Mersch 2015, pp 462-3 and 466-7). The study of possible influences and exchanges through not only architectural forms but also the construction technology and structural design of these buildings can contribute to a deeper

* **Corresponding Author**

*(d.theodossopoulos@ed.ac.uk) ORCID ID 0000-0002-9179-6950
(christiannav@hotmail.com) ORCID ID 0000-0001-7272-5658

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understanding of the new conditions in the Frankish Morea, in particular technology developments.

As part of a wider ongoing project which examines the architectural technology landscape of the Principality, this paper assesses these issues through analysis of stone vaulting in churches, usually a key driver of the structural and spatial layout in Gothic buildings of the time. Churches may have been the most controversial field of the Frankish architecture due to dogmatic and cultural differences between the Roman and the Eastern churches and therefore this allows the exchanges between the two cultures to be more clearly tested.

The most prominent Frankish church surviving today is Saint Sophia in Andravida, the *Andreville* capital of the Principality. St Sophia is currently the only extant monument of the medieval town and offers therefore a unique example of how these new architectural schemes and technology were transplanted into a politically and culturally foreign environment. Although the building is only partially preserved, the vaults at the apse are almost intact (Fig. 1). Using them as a case study, the aim of this work is to examine possible cultural and technological exchanges as they can be identified through the vaults' architecture, construction process and structural behaviour. The performance of their whole system will be analysed by structural assessment of the vaults, as also assumptions about the design process.

The study also explores how a foreign design was imported by the new patrons and their agents the Mendicant (beggers) monastic orders, and the degree it was conditioned by the collaboration with local masons and the use of local material resources (Ousterhout 2008). This study can therefore provides more critical insights into design exchanges in Medieval Europe, bringing a different dimension to the mobility of central European workshops (e.g. German ones in 15th-century Castille, French ones in Angevin Naples in the 13th century etc).

Figure 1. The vaults over the apse in Hagia Sophia, Andravida

2. METHOD and CONTEXT

The main buildings of the Principality have been studied stylistically and historically (e.g., Athanasoulis 2013; Olympios and Schabel 2020, Campbell 2018), framed within meticulous earlier outlines of the history of the state (Bon 1969) or the spiritual and cultural appearance of the Mendicant monastic orders (Kitsiki 1979), but less has been written on their design and construction or the associated building culture. Grossman (2004) has a thought-provoking view of the period as an encounter between Western and Byzantine practices that lead to a new hybrid society and architecture. These buildings constitute Gothic architecture's most persistent expression in Greece and a brief reading of Byzantine architecture before the Frankish period is needed to map any possible technical exchanges.

2.1 Contemporary technical trends in Gothic and Byzantine architecture

The contact between the two cultures in the Morea was not peaceful initially but came in a period of technical refinements for both. The construction of Gothic cathedrals in France had reached large scales, like Chartres (1194-1264) or Amiens (1220-1266), through the continuous optimisation of structural schemes in stone like vaulting and vertical load-bearing elements (wall elevation, engaged piers). Ribs became important in the geometric resolution and materialisation of the difficult joints at the intersecting webs and were used eventually, together with the shafts from the piers, to visually unify the entire structure (*concordance*). Furthermore, the fusion of local styles into new universal Gothic forms were accompanied by the attitudes of the new mendicant orders for visual simplicity (Frankl 1962, p 150). These advancements permeated all scales of

church-building at the time, so it is interesting to investigate whether they were transferred in the Morea.

Mainland Greece at the end of the Middle Byzantine period (843-1204) had gained once again an important role within the Empire (Mango 1978). Church architecture then was of a relatively small and intimate scale, extensively expressed in parish centres, which aimed to be perfect paradigms of the liturgical aspects of the Orthodox Church (Mango 1978; Ousterhout 1999).

The design trends of Byzantine churches that matter in this encounter focus around their interior space which is reflected in the strongly plastic treatment of the exterior (Mango 1978). The typical Byzantine hierarchy of the central dome and other elements shedding loads towards the vertical enclosure is extensively articulated in the smaller churches of the area.

Differences in the rituals can be seen at the emphasis on processional axes focusing on the single point, the altar, in the West in contrast to the centralised routes of the Byzantine church, even if basilican (axial) layouts were also without reaching though the gradual disintegration of the envelope as in Gothic architecture. Hierarchy in the construction plan was therefore important in both worlds but expressed with different means.

2.2 Frankish Architecture in the Morea

The Principality of Achax`ia (1205-1430) was led by the Villehardouins until 1278, when power was taken by the Angevins of Naples. Andravida was chosen as the capital and as is attested in the *Chronicle of Morea*[1], the official "narrative" of their state, the Princes built there their Palace, the church and hospital of St James, the church of St Stephen and that of St Sophia, where also civic functions like the Great Court took place. Although mentioned in various sources up until the early 20th century (Lambros 1916, 480-1; Lambros 1923, 101-3; Miller 1908, 97, 146), two of the churches, assumed to be St James and St Stephen, have little confirmed traces.

Other major new churches include St. Francis in Glarentza (*Clarentia* or *Clarence*) where the Principality's capital moved in the 1250s, which had vaults at the apse only, and several monastic churches that became important as the Principality was asserting itself, e.g. the Cistercian monastery at Zaraká (*Saracez*) in Stymphalia (ca. 1226-ca. 1263), its sister abbey of Notre Dame at Isova (ca. 1211-1263), and the church of St. Nicholas erected after the latter was burnt down (Olympios and Schabel 2020, p 165).

These Frankish churches were larger than their Byzantine contemporaries and had longitudinal basilican layouts, with no tripartite arrangement in the internal elevation, apart from some pointed arches at the windows. The ruinous state of the buildings today provides fragmentary information on the design of stone vaulting. There was probably no concordance of ribs with the shafts and St Sophia's intact vaulted choir has its ribs springing from corbels at their impost. As they are the only surviving genuine ribbed vaults, their technology is worthy to compare at a later stage of this project with the un-ribbed barrel vaults at Chlemoutsi.

The churches were commissioned by the new rulers for religious and possibly propaganda purposes and St Sophia may have been the flagship of the Princes in an urban context. This architecture imported by the new, foreign ruling class met local design attitudes that were less formulaic about styles, with more emphasis on the iconographic programme. Study therefore of the balance between patronage and building culture offers some interesting dimensions. In their construction, local materials like limestone were used but primarily brick was employed for the solid shell and there is a conservative exploration of structural efficiency and load-bearing capacity for vertical and shell-type loads in this new form.

2.3 The Church of St Sophia and its Dating Issues

The most intact Latin church of the Principality and at the same time a very enigmatic monument is St Sophia. As mentioned, it is the sole remain of *Andreville*, the first capital of the Villehardouins. Surrounded tightly by the modern town, only its east end is still standing today consisting of a sanctuary flanked by two side-chapels, all covered by ribbed cross vaults. The nave and side aisles are preserved only at foundation level, while the west end of the church is currently buried under a modern asphalt road (Fig. 2).[2] Despite its better state of preservation and the fact that the church has been studied by many scholars since the early 20th century (e.g., Traquair 1923; Bon 1969; Kitsiki 1979; Sheppard 1985 and 1986) its foundation date, history, and later uses remain obscure[3].

Contrary to the rest of the Frankish churches of the area, there are barely any mentions of St Sophia in literary sources, while sometimes these scarce pieces of information seem to contradict each another: St Sophia is assumed to have been the cathedral of the Bishop of Olena at least since 1205 (Rodd 1907, 174; Traquair 1923, 73) and also the

[1] The *Chronicle of the Morea* arrived to us in three versions: Greek, French, and Catalan, while there is also a summary of the Greek one in Italian. All three relate the history of the Principality, but they cover slightly different periods and do not always agree in detail. Occasionally one of the versions adds particular details lacking in the others and *vice versa*.

[2] The outline of the church could still be traced in the late 19th and early 20th century, see Christianike Archailogike Hetaireia, Deltion A' 1892, 98; Rodd 1907, 174; Traquair 1923, 73.

[3] According to Traquair ruins of a minaret to the NW of the church and remains of a mihrab in the interior indicate its use as a mosque during the Ottoman era (Traquair 1923, 73). Although this assumption is supported by Bon (Bon 1962, 557) and Kitsiki (Kitsiki 1979, 70), Sheppard doubts it (Sheppard 1985, 208).

court chapel of the Villehardouins with mentions of its religious and civic uses found in the *Chronicle of Morea* (e.g. Schmitt 1904, 380, 481). Yet according to the *Chronicle*'s Aragonese version, the only one making an explicit reference to the church origins, it was founded after 1264 by prince William II as a Dominican establishment (Morel-Fatio 1885, 77). Given that all references are rather imprecise, besides the local tradition, there is no absolute evidence to identify the surviving ruins with the cathedral (if there was one) or the church of the Dominicans[4]. The small-scale excavations carried out over the years either by the local Ephorate or others (The Minnesota-Andravida Project (MAP), see Cooper 1996; Sheppard, 1985 and 1986) have not yielded any conclusive results about the identity or dating of the building. For convenience therefore, the church will still be referred to simply as St. Sophia.

Especially the latter is a rather controversial subject as different scholars suggest slightly different time periods: E.g., Traquair who was the first to study and survey St Sophia in some detail, thinks that it was founded in the first quarter of the 13th century by Geoffrey de Villehardouin I (1210-1228/30), but the part which survives today he dates to the early 14th century built either by William de Villehardouin II (1246-78) or during the first years of the rule of the Anjou (1278-1376) (Traquair 1923, 76). Sheppard agrees with Traquair on the founding date but he is of the opinion that the existing vaults were added under the rule of William II before his imprisonment in 1259 (Sheppard 1985, 211). Bon believes it was built shortly before 1250 after the Dominicans' settlement in the Peloponnese (Bon 1969, 547), Kitsiki-Panagopoulos places its founding sometime after 1240, in the early years of the reign of William II (Kitsiki 1979, 66, 77), while Lock thinks it was between 1228 and 1264 (Lock 2013, 217, 232).

With the evidence currently at hand a firm conclusion cannot be reached (dates converge around 1240-59), nevertheless the dating of the church and the identification of its different construction phases is important not only for placing it in a wider historical and cultural context but also for interpreting its form and structure (i.e., Mendicant orders had certain architectural habits in accordance with their customs and apostolic missions and their buildings had to follow specific construction rules, so the Dominican churches reflect the order's limited resources and insistence on austerity and simplicity, see Coulson 1996; Kitsiki-Panagopoulos 1979, 65).

[4] For example, the early 19th-century traveller F. Pouqueville who saw all three Frankish churches of the town standing, does not identify the bishop's church with St. Sophia (Pouqueville 1827, 367) and although the presence of Dominican foundations in the Morea in the early 14th century is documented, there is no evidence for Andravida itself (Coulson 1996, 50).

2.4 Method and the Research Project

The exploration of the technological history of the church will therefore require four research directions: historical-critical analysis; technology transfer; construction and style; structural analysis. This paper covers the last two areas primarily using bibliography, published surveys and a photographic overview from the authors (in 2008). The vaults will be analysed with Finite Element software and since they are the major structural element of the church, their behaviour inevitably conditions the stability of all the remains of the choir.

3. ARCHITECTURE and CONSTRUCTION

The work by Sheppard and subsequent publications appear as the most extensive and direct surveys of the monument, and some of their hypotheses on the history of the fabric are explored in this work or are suggested for future research.

St Sophia was a three-aisled basilica with no obvious transept and a square sanctuary of two bays flanked by two side chapels. Although it is not preserved in its full length today, from earlier surveys we know that it was about 45.50 m long by 18.85 m wide (Fig. 2), a substantial building[5]. The archaeology has showed that the nave had an arcade along the side aisles carried on rather slender single shaft columns, four of which lie still *in situ*[6], while the walls ranged in width between 0.90 m (N chapel) and 1.20 m (S chapel)(Cooper 1996, 32)[7]. The church was built mainly with local coursed poros stones (Kakouris 1979, 156), but red sandstone blocks, marble spolia as well as uncoursed rubble were used at certain places. Bricks and tiles were occasionally used as pinnings to level the courses and in the construction of later openings, so the masonry can be considered to be bonded well for structural purposes. The quadripartite ribbed cross vaults over the choir and the chapels are very well-preserved today. On the contrary, the nave and the side aisled were most likely covered with wooden trusses, with no trace of vaults springing or arcade bonding on the choir (Sheppard 1986, 142), meaning the choir can be studied as an independent structure.

[5] The church was first measured by the Christian Archaeological Society in 1891 (Christianike Archailogike Hetaireia, Deltion A' 1892, 98) and although the later plans of Traquair and Bon give 53.70 m and 54.00 m respectively as the length, the more recent calculations of the MAP seem to corroborate the initial measurements (Cooper 1996, 29-30).

[6] In the area around the church there are parts of four blue-grey granite shafts, while until the late 19th century there were another four which were later moved to the cathedral of nearby Lechaina (Lamprou 1923, 102). The dimensions of both sets seem to match the height of the nave colonnades as indicated by the surviving impost blocks in the sanctuary's west wall (Cooper 1996, 33).

[7] According to Traquair the now buried western wall was considerably thicker than the rest (approx. 2.00 m) suggesting the importance given to the church's western front (Traquair 1923, 73), however, according to MAP's calculations it was no more than 1.00 m thick (Cooper 1996, 33).

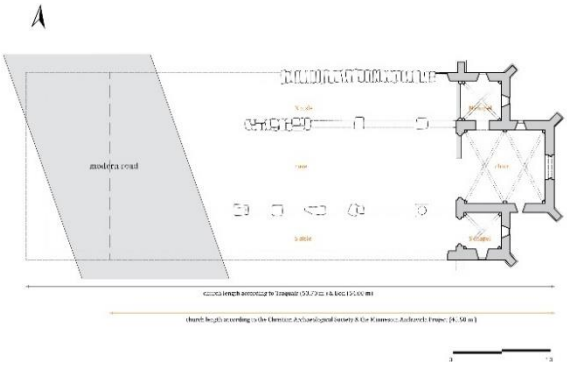

Figure 2. Plan of the church (after a combination of plans by Bon and Sheppard)

The high vaults are quadripartite, ribbed cross vaults, in a brick and stone course rubble (Fig. 3). The apse span towards the nave is 6.65 m and its width L is about 7.7 m wide, with the first bay being 4 m long and the second 4.4m. It was not possible to evaluate the overall height of the apse, but what matters here is the rise of the vault from its imposts to the keystone, which was assessed as F=5.73 m (Traquair 1923). The vaults geometric study shows the third point rule was followed for the design of the intersections and the ribs could have been built firstly to define the formwork. The resulting radius R is 5.9 m and was further used to trace the transverse arch of the apse towards the nave (triumphal arch). The arches along the lateral walls are then traced as projections of the diagonals on the wall plane.

On the side of the apse there are chapels that resemble the Byzantine pastophoria, with overall plan dimensions 3.95 x 3.65 m. Their ribbed vaults abut the high vaults by counteracting the line of thrust from the high vaults with their own thrust, assisted by the spandrels, the fill at haunches and the rather thick transverse walls (measuring between 0.94 and 1.02). The difference in rise between apse and chapels show the vaults were designed for this function of containing the thrust, which will be evaluated in the structural analysis of the vaults.

Figure 3. The ribbed vaults of the apse

The thrusts of the vaults fall furthermore inside the heavy pier buttresses built at the corners of the apse (Fig. 4) and only limited natural light gets in through pointed windows or lancets. The design of the vaults is plain, functional and well executed but it is not clear if extension of stone roofing to the nave was planned.

Figure 4. The diagonally laid pier buttresses at the exterior of the apse

Byzantine cloisonné brickwork bonds were used in the Morea (see the contemporary Byzantine churches in Glatsa, Merbaka, Manolada) and here they are attempted systematically only as decoration at the choir. On the external surface of the wall brick tiles were inserted probably during early restorations (Sheppard 1985), a point that needs clarification in future stages of this project. Overall, the masonry is coursed rubble that re-used ancient spolia and typically was meant to be visible. The vaults are formed of stone blocks, closely glued with thin mortar joints in a regular pattern (Fig. 3). It is clear an attention to the details in construction, reminiscent of the earlier vaults at the nearby Chlemoutsi Castle (1220-23). The Villehardouins showed they could invest in the quality of their buildings where needed and employ masons who could fulfil their aspirations.

As mentioned before, it would make sense to form the edge of the transverse vaults by projecting the ribs on the wall but apparently there was an effort to use for vaults and ribs the same radius, creating an awkward geometry which was not

possible to materialise with the available expertise (Theodossopoulos 2009). The haunches had to follow this twisted pattern and hide behind the projection of the ribs and this peculiar detail was resolved by changing the coursing of the tiles to build a more solid cone (Fig. 5). All these techniques would not be visible as the vault was covered by plaster and there are traces of colour from creating a geometric pattern trying to simulate a stonework on the lateral walls. Some care of the detail in building the vault is quite visible, with careful adjustments and finishing of key elements, like the joining of the ribs on the corbelled support or the standardisation of the rib voussoirs as seen across all arches in the vaults.

Figure 5. The ribs and springings of the vaults

This overview shows an architecture that is consciously generated from the pointed arch, not merely making adjustments of the circular arch that was more in use in Byzantine vaults, indicating clear intentions by the patrons. From structural point of view, the haunches could have efficiently reduced the span required for the formwork and the layout of straight courses show no intentions for a domical geometry. However, the vaults do not represent the technical and aesthetic contemporary refinements of the type in Europe: the intersections along the groins are highlighted and strengthened by stone ribs of a heavy torus section (Fig. 5) and there is no attempt to unify the underlying space with ribs that extend as shafts to the elevation. Anyway, some authors, and among them Sheppard (1985) believes the ribs were attached later on the groins, at the time when the chapels were added, as the fallen rib on the north chapel indicates. This is crucial for the unity of the design and needs closer inspection in further research, to detect if the masonry along the intersections is disturbed or re-worked.

4. STRUCTURAL ANALYSIS

Analysis of the structural performance can assess the effectiveness of some of the design strategies and then address some of the historical assumptions mentioned earlier: whether ribs were integral to the shell (or used as permanent centering), the efficiency of buttresses (especially the diagonal arrangement), walls or aisle vaults in containing the thrusts. This may justify the construction sequence (aisles after the high vaults) and indicate the portion of the walls necessary for stability (and how wide openings could be made) and consequently if the high vaults were added safely later over pre-existing walls.

A Finite Element (FE) numerical model was formed to analyse the structural behaviour of the vaults under the dead load of the structure. The vaults were simulated like shells with the program GiD (as pre-processor) and Abaqus for the FE analysis and appropriate elements were used for the webs (shell) and the ribs and arches (3D beams) (Theodossopoulos 2003).

This simulation is only an initial approach to assess how the form testifies the various hypotheses for their thrust containment. A uniform thickness of 250 mm was assumed and the masonry was considered as isotropic, using values for a thin brickwork bond (elasticity modulus set conservatively as 5 kN/mm^2 (IStructE 2005, table 1). Linear elastic analysis under self weight 20 kN/m^3 was performed. Instability due to outward spread of the supports, the action that usually marks failure in vaults (Theodossopoulos 2008), was not assessed in this stage.

For the crucial simulation of the supports, the spandrel walls were modelled as deep arches along the edge of the shell: the width of their cross section was equal to the thickness of the wall (0.6m) and their depth was chosen as 1m to account for the change in the stiffness due to the lancet and pointed windows. The substantial lateral constraint of the side chapels (Fig. 1) was simulated to apply up until 2/3 of the height of the shell.

Under these assumptions, the deflections (Fig. 6a) are overall small, which is mostly due to the continuous elastic analysis, the rigid continuous form of the thin shell and the lateral constraints. Only a detailed 3D survey of the vault could show the magnitude of deformations experienced in its history and therefore the quality of the structural scheme. Also, the squint pier buttresses at the corners were not modelled as a presence or a diagonal constraint, since the stiffness of the supports in the FE model minimises any other effect. The removal of the ribs (Fig. 6b) causes an increase by 25% of the deflections, but follows the same pattern, showing that the keystone of the westernmost vault is most vulnerable.

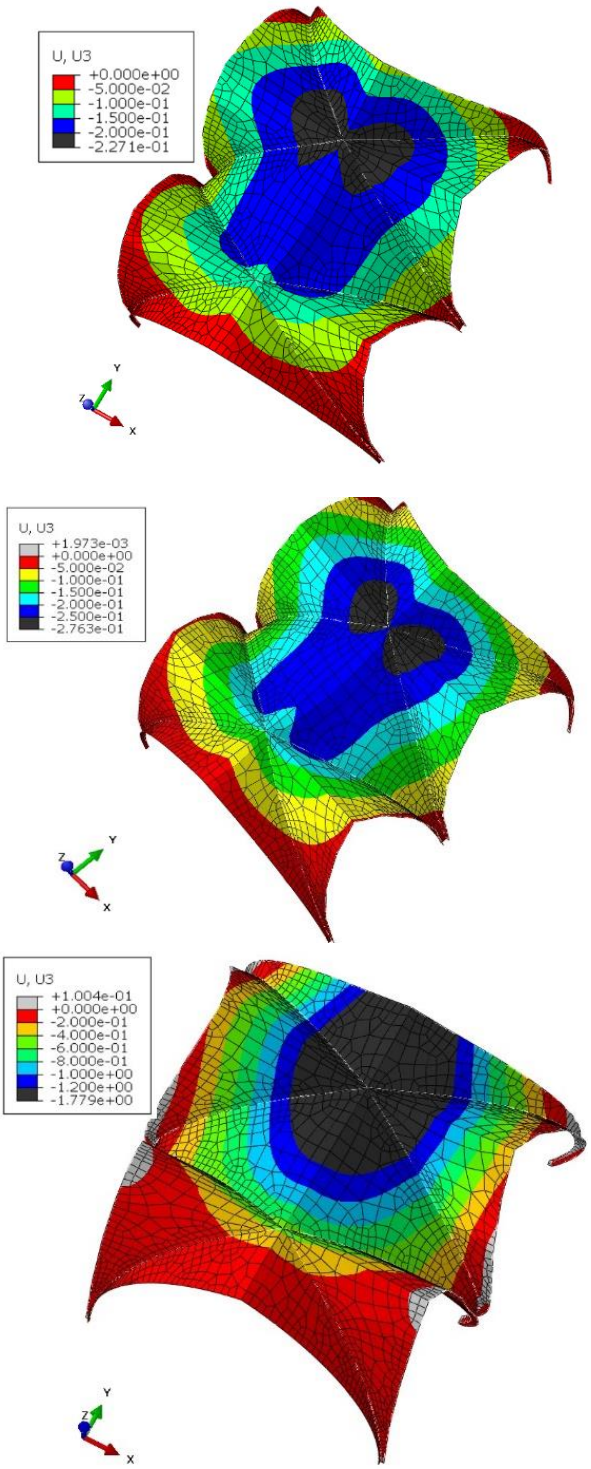

Figure 6. Deflections (in mm) from the analysis of the vault as a shell with ribs (a), without ribs (b) and with ribs but no lateral constraint (c)

Tensile transverse stresses appear along the longitudinal axis at the extrados (Fig. 7a), which show the positive effect of the lateral containment and the pointed form, which reverses the bending moment patterns in typical circular arches (tension at intrados of crown). Axial tensile stresses appear along the restrained wall edges at the intrados (Fig. 7b), which then spread towards the corresponding diagonal ribs.

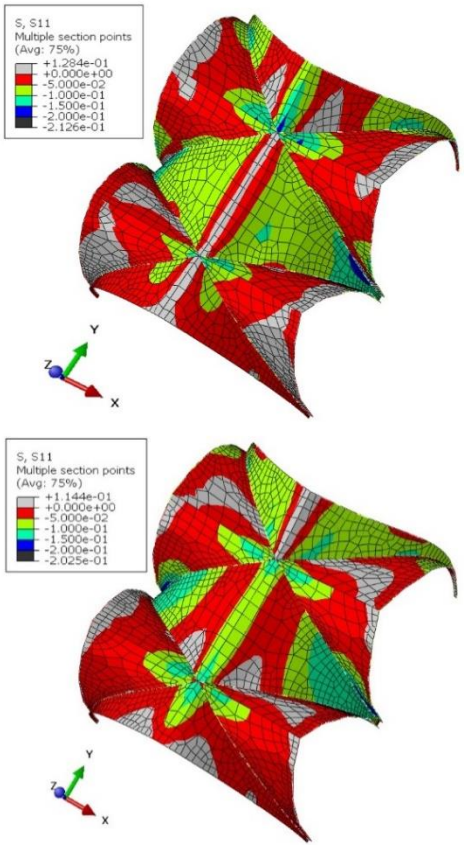

Figure 7. Transverse stresses S11 at the extrados (a) and intrados (b) of the vault with ribs, in N/mm^2

Finally, the effect of the lateral constraints of the chapels and their substantial roofs (Fig. 1) was removed altogether to test a hypothesis they were added later. This caused the vaults to spread differentially, outwards and inwards along the edge, while deflection increased strongly, extending to the west end and corresponding vault (Fig. 6c). This is a large deformation (within the conditions assumed) that would have left permanent effects any later additions of lateral constraints could not cancel. Survey of the vaults and any deviation from the ideal original design can once again clarify this hypothesis.

Seismic analysis should be explored in the next stages of this project, as the Elis area is historically vulnerable and recent earthquakes (2008, 2019) have apparently caused concerns, which resulted in the closure of the monument to the public.

5. REFLECTION ON DESIGN AND TECHNOLOGY TRANSFER

The analysis showed an overall successful and confident structural design for the vaults, which was probably carried out by an experienced, West-trained stone mason. Despite that, vaulting was not followed at the rest of the church and the timber roof that covered the nave was due probably not only to the restrained decorative attitudes of the Dominicans (if those were the founders) but also

the lack of major architectural projects later by the Angevins, who after they took over from the Villehardouins in 1278 did not invest in the prosperity of Morea.

While the vault design could have been of direct Western import, the construction of the walls show the opportunities for collaborations with the expertise of the native masons. In most Byzantine churches of the time, the walls use the cloisonné pattern - framing squared stone blocks with bricks (Fig. 5). This type of bond, together with the tri-partite apse (which suits Eastern rites) and the use of brick masonry at the vaults come from the native building culture and can be seen in many churches in Elis. Heather Grossman's (2004) wider comparison of churches from both rites of the period that explored the case for a hybrid Moreote architecture serving both cultures, showed this architecture was complemented eventually by elements at the ornamentation, like the use of crocket capitals.

Vaulting is a more intensive area for technological transfer and it is believed that like Saint Sophia in Andravida, the churches of Zaraká (Campbell 2018) and St. Francis in Glarentza (Athanasoulis 2005) had such roof. In these cases, ribs seem they have been added along the intersection once the webs were built and thus did not have a function during construction (as can also be seen at the fallen ribs in the North chapel in Andravida and other repairs – see Sheppard 1985 p 206). In the native Byzantine practice, brickwork was used as a simple material for construction, with limited aesthetic treatment, and for adjustments of the form on-site. The joints however would be quite thick so mortar would set primarily because of the warm weather otherwise, in wetter conditions the buildings could easily distort. This is why any Western technology prototypes would be expected to have thinner joints and ashlar blocks.

Stone vaults apart from benefits in roofing, would be considered as extravagant elements, especially among Mendicant orders declaring and living the poverty like the Dominicans, who would restrict their use only at the apse (Kitsiki 1979) - if they were associated with Saint Sophia then the vaults are in line with this attitude. It was shows that even these plain vaults showed advanced technology and distinct articulated space qualities that could have been actively used by the patrons to promote the Principality and their Roman Catholic traditions to both the working and the upper native classes.

Flying buttress systems were not applied anywhere in Latin Greece. This is due to the relatively small scale of the churches and associated spans but also the lack of great ambition by the Princes which, in contrast to Lusignan Cyprus, did not have the conditions for producing such complex elements.

6. CONCLUSION

Gothic Architecture was a highly rationalised construction system that forms stone masonry into brave, efficient and slender stone skeleton-like schemes. This may have inspired the new patrons in Greece and the issues when transferring such schemes into the less technically efficient culture of the area at the time are explored in this work. The basic constructional and structural analysis conducted showed limited direct exchanges between the two cultures, which enabled though a successful implanting of Gothic ribbed vaulting in one of the major buildings of the period.

These vaults have a spatial concept that is quite far from the liturgical practices of the local Greek Orthodox architecture, where space is articulated by plastic treatment of the volume, and has no compositional elements like shafts and ribs. The apse however shows a common ground (Theodossopoulos 2009), the solid walls and vaults provide a controlled amount of light and thermal comfort. The cultural exchanges that may have taken place were highlighted by the Minnesota project (Sheppard 1985, 1986) which identified a later Frankish phase when openings at the apse were regularised and down-sized. This can show a need to integrate even contemporary Byzantine preferences for mystical and focused church spaces.

A measured survey of Saint Sophia can highlight deformations that may verify the structural design and clarify the construction phases. This can further demonstrate the processes of adaptations of original vaulting schemes and eventually the extent of cross-fertilisation between Western architectural intentions and local building practices. Any offsets should be distinguished carefully between adaptation efforts by inexperienced masons and structural problems by a weak design.

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Author contributions

Dimitris Theodossopoulos: Conceptualization, Methodology, Software, Writing-Original draft preparation, Validation
Christianna Veloudaki: Visualization, Investigation, Writing- Reviewing and Editing.

Conflicts of interest

There is no conflict of interest between the authors.

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