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by Rocco Leonardis

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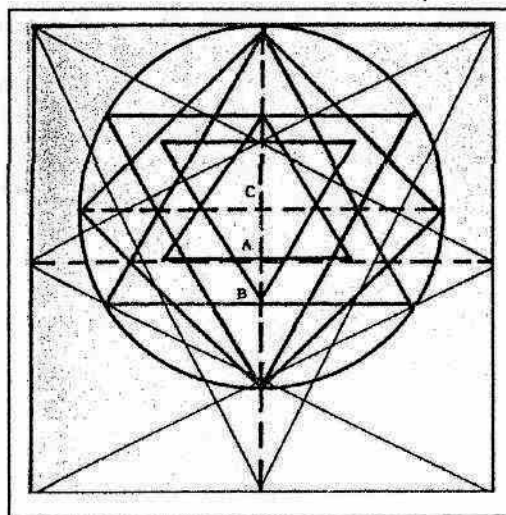
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Conversazione dell'Architetto **ROCCO LEONARDIS**

Adjunct Professor, Fashion Institute of Technology of New York
che parlerà della sua ricerca:

I segreti dell'Architettura Medievale



Pianta di Santa Sofia di Benevento

Interverranno:

la Prof.ssa **STEFANIA TUZI**
Università degli Studi di Roma "La Sapienza"

il Dott. **PAOLO LUCARELLI**
saggista

GUSTAVO RAFFI
Gran Maestro del Grande Oriente d'Italia.

L'Architetto Rocco Leonardis Professore Aggiunto al *Fashion Institute of Technology of New York* di passaggio a Roma, parlerà della sua ricerca sui segreti dell'architettura medioevale. Tema dell'incontro: la Chiesa di Santa Sofia di Benevento.

Si tratta di un edificio, costruito nel 760 A.D., che fornisce una chiave di lettura del modo di procedere medioevale nell'ambito della progettazione e del disegno architettonico.

L'eccentricità della pianta della Chiesa infatti può essere spiegata solo sulla base di un approccio geometrico al disegno architettonico che assolve, contemporaneamente, un compito pratico e simbolico. La dimensione simbolica si presta ad una lettura esegetica della forma architettonica, prassi estendibile a tutta la produzione medioevale.



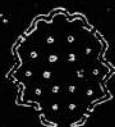
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Convegno di Studi



S. Sofia: il mistero della sua costruzione tra geometria e simbolismo

Benevento, Sala del Reduce - 6 febbraio 1998 - ore 17,30

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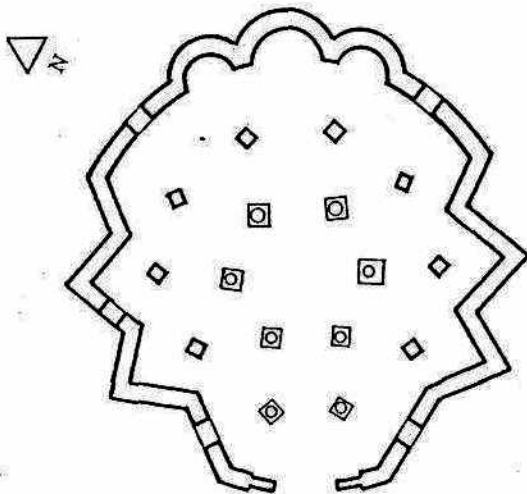
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The Plan of S. Sofia: A View into Early Medieval Design

*The philosopher Aristippus, a follower of Socrates,
was shipwrecked on the coast at Rhodes,
and observing geometrical diagrams drawn upon the sand,
he is said to have shouted to his companions:
«There are good hopes for us; for I see human footsteps!»*

*Vitruvius, VI. Praef. 1
(trans. Frank Granger)*



1. Plan of S. Sofia, circa 760 AD

About 760 AD, a unique church dedicated to Santa Sofia was built in the ancient Italian city of Benevento whose plan provides a key to an understanding of the early Medieval process of design (fig. 1).¹ There is a certain eccentricity to its plan, and the explanations and solutions for it offered here are based on a geometric approach to architectural design that has a long, well-established tradition in the Mediterranean world. This geometric process is at once simple and practical, allows for a direct application on the building site, and yet is susceptible to a symbolic exegesis. That continuity in techniques of design from antiquity to the Middle Ages existed is widely assumed but not well documented. By the analysis of the church presented here, I shall show

that its designer used the same preliminary approach to architectural design that was used widely in the Greco-Roman world, a process of design based on the initial production of a geometric diagram in order to lay out its proportions, its liturgical spaces, and its decoration.

The exterior of Santa Sofia was altered over the centuries and is partially obstructed by contiguous buildings, so that it gives little hint of the experience to be found within (fig. 2). When standing in the church, one

¹ I am eternally grateful to my father, Nicola Leonardis, for training me in the process of geometric design. I am indebted to the American Academy in Rome, its former director Prof. Caroline Bruzelius, present director Prof. Lester K. Little, and the efficient staff, especially Pina Pasquantonio and Ann Coulson, for their kind assistance and support. I am very grateful to the good people of Benevento: the Comune di Benevento Assessorato alla Cultura, the Camera di Commercio Industria Artigianato Agricoltura, and the Ordine degli Architetti della Provincia di Benevento, who sponsored my lecture on this topic to the public in Benevento on February 6, 1998 (entitled *S. Sofia: il mistero della sua costruzione tra geometria e simbolismo*). I wish to thank Professor Elio Galasso, Director of the Museo del Sannio, for permission to measure the church, and his helpful staff; Don Giovanni Giordano, Monsignor of the Arcivescovado di Benevento; and Donato Callisto, Dr. Luigi Callisto, and the entire Callisto family of Benevento. For their guidance I thank William Breger, Dorothy Irwin, Angela di Maria, Margaret M. Miles, Gernot Windfuhr, and Robert Zoller. All photographs and drawings are by the author. Charles Oman, *Europe* 476–918, London 1895, p. 348–349; Edward Gibbon, *The History of the Decline and Fall of the Roman Empire*, London 1788, Vol. 5; Paolo Verzone, *The Art of Europe: The Dark Age*, New York/Toronto/London 1969, p. 217–218; Karl Baedeker, *Handbook for Travelers*, Part 3, Southern Italy and Sicily, Boston 1875.



2. Exterior side view of S. Sofia

feels the presence of geometry without being able to identify the overall geometric form (fig. 3). This is in stark contrast to the sensation offered by numerous contemporary, and near-contemporary structures, whose shapes are immediately perceptible.² The absence in S. Sofia of a conspicuous axial bilateral symmetry, particularly surprising in a church, prompts an examination of its plan. Here a startling picture begins to unfold. The church has a single axis, along which sharply defined angles, corners, and curves have been balanced (fig. 4). These forms are equally apparent in both the interior and the original exterior, suggesting that the forms themselves were for some reason valued above convenience of construction or the conventions of Catholic church design, in which a simple form, such as a rectangle, an octagon, a circle, or a square, is chosen to best enhance the liturgical requirements along an axis, with a focus toward the altar. S. Sofia's unprecedented plan provokes questions about the methods and intentions of its designer, and the place of the church in the history of architectural design.

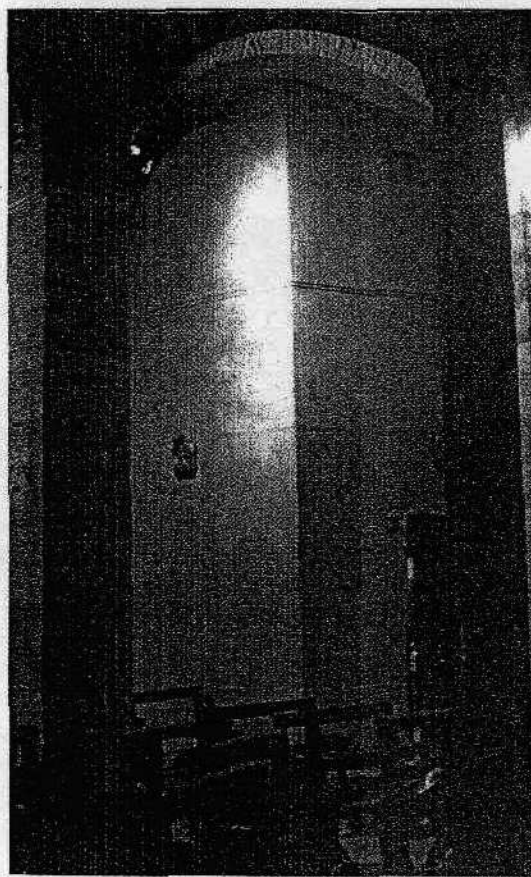
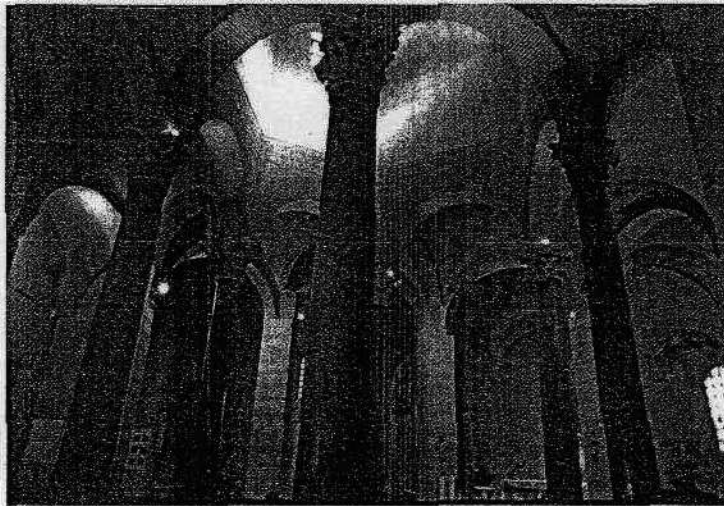
Among architectural historians who have discussed S. Sofia, most have recognized a geometry in its plan, but none offers a satisfactory explanation of the incorporation of dissimilar forms. Descriptions of the church tend to be cursory and simplistic. The most frequent assertion, that the «eccentric» church is naïve, or «provincial», in design, is not convincing, since

«provincial» design is generally marked by second-rate materials and uneven craftsmanship, and furthermore in this period no one «center» of construction was dominant. On the contrary, the building at hand is made of the finest materials and was constructed with the most advanced techniques of its day.³ The building is constructed primarily of tufa, coursed with a layers of re-used red Roman brick (*opus mixtum*). There are a number of conspicuous re-carved marble and limestone architectural blocks from the Roman period used

² Walter Lowrie, *Monuments of The Early Church*, New York 1901, p. 131–152; Vitaliano Brunelli, *Storia della Città di Zara*, Venezia 1918, Parte Prima. For earlier examples, see David M. Jacobson, Hadrianic Architecture and Geometry, in: *American Journal of Archaeology* 90, 1986, p. 69–85, and the larger discussion of geometry in Roman architectural design in Mark Wilson Jones, *Principles of Roman Architecture*, New Haven/London 2000, chapter 5; especially useful: Bratislav Pantelic, Applied geometrical planning and proportions in the church of Hagia Sophia in Istanbul, in: *Istanbuler Mitteilungen* 49, 1999, p. 493–515.

³ Gustavo Giovannoni, *La Technica Della Construzione Oresso I Romani*, Roma 1972, rep. of 1925 original ed.; Josef Durm, *Handbuch der Architektur*, Stuttgart 1905; G. C. Mars, *Brickwork in Italy*, Chicago 1925; James C. Anderson, *Roman Architecture and Society*, Baltimore/London 1997, p. 139–151. For a study of techniques and materials used somewhat later in the sphere of Byzantium, see Robert Ousterhout, *Master Builders of Byzantium*, Princeton 1999, p. 58–85, 128–156.

3. Interior view of S. Sofia



4. Interior view of triangular fold in wall

at crucial junctures in a supporting position just above ground level, partially framing a rear exterior door, and completely framing the front door. In the interior there are re-used Roman columns, capitals and bases of granite and various marbles. Above them is concrete and brick vaulting used to support the roof and lantern. Originally the interior walls were decorated with frescoes, of which a few fragments remain.⁴

The use of *opus mixtum*, the premier coursing technique of its era, may be compared to St. Ilario, a nearby church built about sixty years later, whose design is of a high quality but whose structure was formed of rubble masonry, requiring a lower degree of craftsmanship and cheaper materials. Furthermore, S. Sofia was probably built as part of the palace-complex presided over by the Duke of Benevento, Arichis II (758–787), who controlled the monastery of Monte Cassino, the intellectual touchstone of the period. In fact, S. Sofia was upon its completion named after Hagia Sophia in Con-

⁴ St. Zacharias of Cappadocia is portrayed in one of the fragments, in a style of similar to that of surviving frescoes in a Longobard church in Castelseprio, near Milan. See M. Rotili, *L'Eredità dell'antico a Benevento dal VI al VIII Secolo*, in: *Napoli nobilissima* XIV/4 (July-Aug. 1975), p. 121–128, and R. Naldi, *Ritorno al chiostro di Santa Sofia a Benevento*, in: *Bollettino d'Arte* 76 [75], 1990, p. 25–66; for Castelseprio, see G. Chierici, *L'Architettura di S. Maria di Castelseprio*, Milan 1948.

stantinople, as noted by Erchempert of Monte Cassino in his *Historia Langobardorum Beneventanorum*.⁵ Given the sophistication, maturity, and advanced technique inherent in this context, how could the design of S. Sofia be dismissed as simply naive?

The church was damaged by earthquakes more than once. In the 17th century some of the most serious damage occurred when the later addition of a tower at the entrance crashed down onto the roof of the building during an earthquake (1688). This must have required the rebuilding of some parts of the lantern, and perhaps also some of the arches supporting it before the church was reinaugurated in 1697. Collateral damage may have included two of the internal supports of the structure to the right and left of the entrance.

When Antonio Rusconi excavated and restored the site, from 1950 to 1957, he found that the plan itself was original, and not altered as had been thought previously.⁶ Although he describes the plan, Rusconi does not speculate on its geometry or the logic of its design. Hans Erich Kubach, in his classic work *Architettura Romanica*, describes S. Sofia as »polygonal« and »star-shaped.«⁷ Paolo Cavuoto proposes that S. Sofia might have been planned with a geometric pattern.⁸ He saw a similarity in architectural form with early Armenian Christian structures such as churches, chapels, and tombs.

Indeed some of the geometry found in S. Sofia is identical to that described by the eleventh-century historian and astronomer Abu Rayhah al-Biruni (973–1050), in his *Book of Instruction in the Elements of the Art of Astrology*.⁹ It is worth noting that besides being a native of Armenia, al-Biruni lived in India for almost forty years and wrote a book on the country. Because of the volatile expansion of early Islam (which at S. Sofia's completion in the eighth century was less than a hundred years old), the potential relevance of this movement to the church plan justifies a brief overview.

Benevento: A Cultural Polyglot

Benevento's history is one of continuous traffic. From its early Roman days, the city was destined to be a meeting-place of people on the move: the Via Appia, the first of all major Roman roads, leads from Rome to

Benevento, and the Via Traiana, a significant military road, was constructed to link Benevento with Brindisi at the heel of Italy, built to promote success in Trajan's campaigns against the Parthians in Persia. Together these roads allowed for the movement of both goods and knowledge along the southern half-length of the Italian peninsula, and from distant lands such as Palestine, Egypt, and Asia Minor. Traffic both north and south brought a wide range of cultural influences to the city. During the imperial Roman period the cult of Isis flourished in Benevento, attested today by the numerous Egyptian statues found in the area and exhibited in the local museums, and an obelisk of red granite, now in the Piazza Papiniano.¹⁰ In late antiquity Benevento was noted for its valuable location for trade with the Near East. The city's ties with that region, and also with Alexandria in Egypt, were strong.

At the time S. Sofia was constructed, the Mediterranean shores were turbulent with the cultural force of Islam, which was advancing from Mecca throughout

⁵ Herbert Bloch, *Monte Cassino in the Middle Ages*, Cambridge/Mass. 1986, vol. I, p. 264–268.

⁶ Antonio Rusconi, *La Chiesa di S. Sofia di Benevento, in: Corsi di cultura sull'arte ravennate e bizantina, XIV*, Ravenna 1967, p. 339–359.

⁷ Hans Erich Kubach, *Romanesque Architecture*, Milan 1972, English ed. 1975, p. 29.

⁸ Paolo Cavuoto, »La Chiesa di S. Sofia a Benevento,« from the *Museo del Sannio, Centro Ricerche Bibliografiche*. Judson J. Emerick, *The Tempietto del Clitunno Near Spoleto*, University Park/Penn. 1998, p. 389–390, for a review of the relationship between the court of Duke Arichis and the court in Constantinople. Emerick recognizes the »forced« axis through the central hexagon of different colored columns (p. 390, n. 145).

⁹ Abu Rayhah Muhammad Ibn Abroad al-Biruni, *The Book of Instruction in the Elements of the Art of Astrology*, written in Ghaznah, 1029 C.E. Translated by R. Ramsay Wright, London 1934, p. 89, 107, 129, 225. George Mitchell, *Architecture of the Islamic World*, New York 1978, p. 131, 132. For al-Biruni's dates, Benjamin Walker, *Foundations of Islam, The Making of a World Faith*, London/Chester Springs 1998, p. 297.

¹⁰ R. E. Witt, *Isis in the Greco-Roman World*, Ithaca/New York 1971, p. 86, 87, 234; Witt discusses the complex cross-over relationships between various beliefs during the later imperial period (pp. 235–242). For Isis at Benevento specifically, see Hans Wolfgang Muller, *Il Culto di Iside nella Antica Benevento*, Benevento 1971.

the Eastern Mediterranean, North Africa, and on into Europe. Many formerly isolated or semi-isolated religious groups, in places such as Armenia, Palestine, Syria, and Anatolia, were forced into collision with one another as their people sought refuge, hoping to keep their religious and cultural legacies intact in Italy and other parts of the West. As an example, the perfectly proportioned Byzantine church La Cattolica di Stilo, on Monte Stella in Calabria, was built by Armenian monks somewhat later.¹¹ Diverse groups found their way to Benevento. It is not too far-fetched to consider the possibility of influences from distant cultures in the church's plan.

Potentially Related Structures

In his discussion of the Shepherd's Chapel at Ani in Armenia, A. Khatchatrian demonstrated the possible use of geometric patterns in the building designs of early Armenian Christian structures. It was this work by Khatchatrian that was used by Cavuoto in his speculations that a similar geometric formulization might apply to S. Sofia.¹² The most relevant comparison in Armenia, the Shepherd's Chapel at Ani, has a diameter of about five meters, with a folded wall that offers six points of support for a dome, according to a design-diagram based on a «Shield of David» (six-pointed star) with a rotated square: it is the Shield of David, however, that defines the architectural form. There are no interior supports (as in S. Sofia), and the interior effect is not the baroque, nonlinear experience of S. Sofia, but a more rational and continuous space, resembling the Minerva Medica (the remnant of a circular Roman nymphaeum that has a central dome and an undulating interior wall composed of a series of apses). Although the walls of the Shepherd's Chapel are relatively thick compared to the diameter of the structure, the folds of the exterior wall are not as visible in the elevation as in the plan. This is because the angled recesses are roofed, and they read as niches; thus the exterior of the building appears round, a configuration further emphasized by the placement of the chapel on a circular platform. Despite the formal differences between S. Sofia and Armenian work, the significant similarity is that a recognizable abstract symbol is used as a design tool. If not actually

a native of Armenia, the designer of S. Sofia might have had cultural attachments to that area and beyond.

Searching further for comparisons, we find that a rotated square was being used in India for the design of a religious structure in plan about the same time as the date of construction of S. Sofia. In northern India there are two temples dated c. 700 AD that exemplify this technique.¹³ The Siva Temple at Adbhar and the Siva Temple at Dhobini are both the result in plan of placing two squares at 45 degrees to each other, just like the famous doubling of the square to be found in Plato's *Meno* and in Vitruvius. What is of further interest here is that while both structures express the relationship between the two squares externally, the temple at Adbhar (like S. Sofia) does so internally as well.

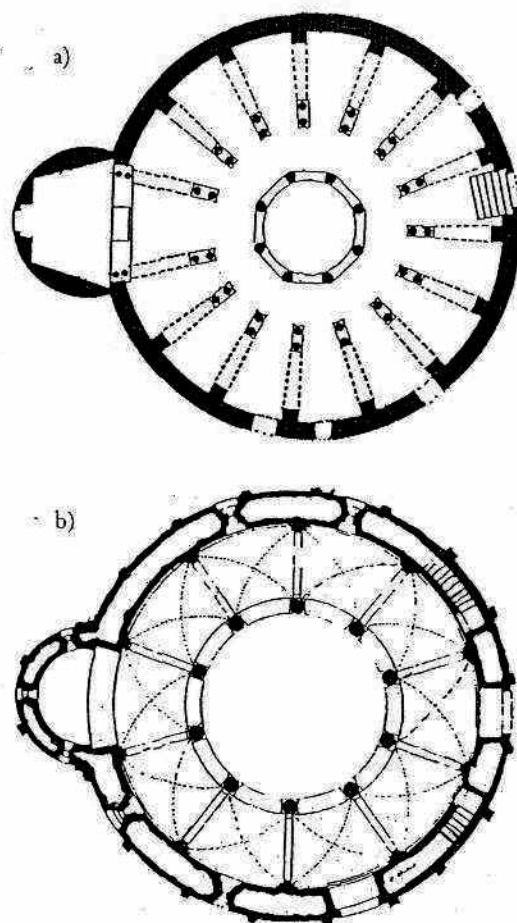
In his *History of Architecture in all Countries* James Fergusson provides the only widely published illustration of the plan of a church at Planes in Southern France of the 11th century which exhibits intersecting sharp geometric forms clearly recognizable (unlike S. Sofia) as triangles and a circle, apparently expressed internally and externally (as in S. Sofia even though not immediately apparent).¹⁴

In the Greco-Roman world many types of structures were centrally planned, including temples, tombs, monuments, nymphaea, parts of residential complexes, and even large public spaces such as theaters. In Rome,

¹¹ Krautheimer notes the continuous (even if at times tenuous) ties between the Italian peninsula and Byzantium from the late sixth century to the end of the eighth century; the Cattolico, was built in the tenth or eleventh century when the area was controlled by the Byzantine empire (according to R. Krautheimer), *Early Christian and Byzantine Architecture*, New Haven 1986, p. 401–402.

¹² A. Khatchatrian, *L'Eglise du Berger à Ani*, in: *Cahiers Archéologiques*, Paris 1952, p. 91–102, especially p. 92 and pl. 26; Cavuto (as note 8). For an expression of angles on the exterior of a centrally planned structure similar to S. Sofia, see Ernst Kuhnel, *Islamic Art and Architecture*, trans. Katherine Watson, Ithaca/New York 1966, fig. 27a, Funerary Tower in Gurgan, possibly 976–1012 CE.

¹³ Michael W. Meister, M. A. Dhaky, and Krishna Dena, *Encyclopaedia of Indian Temple Architecture North India*, Delhi 1988, vol. 2, part 1, p. 246–249. For a discussion of a possible Indian geometric design procedure, see Sonit Bafna, *On the Idea of the Mandala as a Governing Device in Indian Architectural Tradition*, in: *Journal of the Society of Architectural Historians* 59, 2000, p. 26–49.



5. a) Plan of the Baptistery at Nocera, b) Plan of San Lorenzo in Mantova

famous centrally planned structures include the Pantheon built by Hadrian, S. Stefano Rotondo of the later empire, and the octagonal building on the grounds of the old palace of the Lateran in Rome, said to have become the first designed baptistery possibly as early as the fourth century CE, certainly by the time of Sixtus III (432–40). Another well known centrally planned structure is the tomb of Constantine's daughter, Constantina, later used as a church. The plans of these buildings are regular in shape: octagons or circles. Other examples are San Lorenzo in Milan, San Vitale in Ravenna, and the great Hagia Sophia of Justinian in Constantinople. Simple geometrically shaped struc-

tures from the era preceding the construction of S. Sofia are too numerous to list, and are found across a vast area of the Roman Empire. The greatest concentration is seen in the Eastern Empire; later Islamic structures are the inheritors of this building tradition in the East, and testify to the continuity of the centralized plan and its structural innovations.¹⁵ There are two centrally planned structures in Italy, however, that demonstrate the unusual choice of geometry that literally informs S. Sofia. Both the church of Santa Maria Maggiore at Nocera (once a baptistery) near Benevento, built in the 6th century before S. Sofia, and San Lorenzo in Mantua, built afterwards (possibly 11th century), are round buildings with interior supports arranged to form geometric patterns (fig. 5).

Centrally planned buildings readily suggest the use of geometry as a design tool – indeed, historical evidence shows the geometric applications Romans made in their building design. Yet the geometric underpinnings of the Greco-Roman design process are not commonly acknowledged. This matter warrants a closer look.

The apparent peculiarity in S. Sofia's plan is its irregular combination of the overall curve and the zigzag shape. A designer's whimsy, omitting part of one diagram or replacing it with another, could have produced this plan, and the changing dynasties of dukes ruling Benevento during the period of construction might have contributed to a disjointed aspect if patronage was an issue.¹⁶ It seems more likely, however, that the designer of S. Sofia proceeded to create his building with a purpose and with a design process inherited from the pre-Vitruvian world.

The Vitruvian Legacy

In the oldest surviving work written by a practicing architect, Vitruvius refers to illustrations which, regrettably, have long since disappeared. The earliest drawings

¹⁴ James Fergusson, *History of Architecture in all Countries*, London 1893, p. 59.

¹⁵ Heinz Gotze, *Castel del Monte*, Munich 1998.

¹⁶ Hans Belting, Studien zum beneventanischen Hof im 8. Jahrhundert, in: *Dumbarton Oaks Papers*, 16, 1962, p. 141–193.

we have were not part of his work but were rather derived from his descriptions. These drawings are in the *Codex Sebestianus*, drawn during our period of investigation, probably in the eight or ninth century, possibly by Einhard, a biographer of Charlemagne, and a former pupil of Alcuin of York who nicknamed him Einhard Bezaliel, indicating that he was an artisan. Einhard was personally involved with the use of the antique styles of expression both in art and literature in the imperial school of Aachen. Although based on Vitruvius's text, Einhard's drawings are too imprecise and eclectic to be classical, as Hanno-Walter Kruft remarks, describing them as existing in a cultural »no man's land.«¹⁷

The extent to which Vitruvian techniques were used in the early Middle Ages has been debated. Although documentation is scant and some scholars are skeptical, others have found evidence of a tradition continued from antiquity. Walter Oakeshott, for example, states categorically that »Vitruvius was certainly read by Carolingian artists and architects.«¹⁸ Supporting this claim is a letter from Einhard to a pupil named Vussin or Vulfin, in which he mentions his struggle to comprehend Vitruvius's use of the term *scaenographia*. Einhard also sent to this student an ivory model of a temple proportioned according to the rules of Vitruvius.¹⁹

There are further implications resulting from the survival of the geometrical understanding of construction attested by Plato's doubling of the square. This is one of the illustrations promised by Vitruvius but now lost to us – but we do know from this that an ancient architect recommends to his peers the use of a pure geometric diagram as a means of solving a common building problem. Was this, as well as some of the other illustrations, perhaps still in existence in Einhard's day? We of course do not know; yet the method is an easy, practical solution for the problem of calculating areas and building sizes, and that ease and practicality may have encouraged its preservation.²⁰

Because of the dearth of documentation, the missing historical link in the use of geometry in architectural planning since the ancient world has been the early Middle Ages. S. Sofia bridges this gap. Its intricate plan can be explained only by the use of a geometric diagram as a preliminary step in the design process. The

historical record of diagrammatic planning resumes in the later Middle Ages, which left several preserved examples, such as Villard de Honnecourt's lodge sketchbook, Matthaeus Roritzer's 1486 work on pinnacles (*Das Buchlein von der Finalen Gerechtigkeit* and his *Die Geometria Deutsch* [1487]).²¹ Lorenz Lorsche's collection of geometric patterns for stone architecture also demonstrates the need for geometric constructions to solve practical problems and for the process of design generally. All these books also illustrate the persistent use of the doubling of the square and the rotated square.²² The evidence of continuity provided by the present analysis of S. Sofia suggests an uninterrupted application of geometry to the process of architectural design from at least the Greek period through to the present day.

¹⁷ Hanno-Walter Kruft, *A History of Architectural Theory from Vitruvius to the Present*, New York 1994, p. 31.

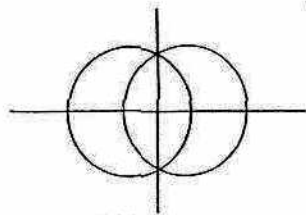
¹⁸ Walter Oakeshott, *Classical Inspiration in Medieval Art*, London 1959, p. 64, 134, pl. 92. For a useful survey of plans and grids, including discussion of the well-known Plan of St. Gall, W. Eugene Kleinbauer, Pre-Carolingian Concepts of Architectural Planning, in: Marilyn J. Chiat and K. L. Reyerson, eds., *The Medieval Mediterranean: Cross-Cultural Contacts*, St. Cloud/Minn. 1988, p. 67–79.

¹⁹ The Altar of Angilbert in Milan, dated to the 9th century, bears visible geometric divisions in the design of its side, similar to the doubling of the square diagram described in Plato's *Meno*, and in Vitruvius. The altar was made by a certain »Wolvinius« who has been identified rather wishfully with Vulfin, the pupil to whom Einhard wrote about Vitruvius.

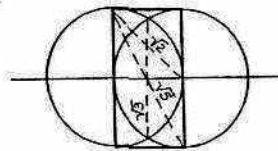
²⁰ This diagram was the old form used by astrologers for drawing up horoscopes which in turn represented a map of the heavens at the time of an individual's birth. Cf. al-Biruni's chart on p. 190 (321) in his book relating astrology to geometry.

²¹ Matthaeus Roritzer, *Das Buchlein von der Finalen Gerechtigkeit*, Regensburg 1486, and *Die Geometria Deutsch*, Regensburg 1487. Both have been published in facsimile by Guido Pressler (Wiesbaden 1965).

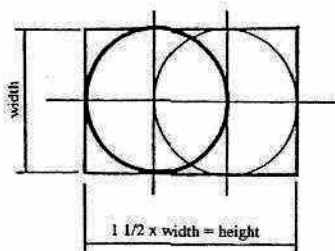
²² Lon K. Shelby, Mediaeval Masons' Templates, in: *Journal of the Society of Architectural Historians* 30, 1971, p. 140–154; James S. Ackerman, Ars Sine Scientia Nihil Est. Gothic Theory of Architecture at the Cathedral of Milan, in: *Art Bulletin* 1949, p. 84–111; F. M. Lund, *Ad Quadratum*, London 1921.



The construction of a simple Vesica Piscis, producing 90 degree angle.



The demonstration of root rectangles within a construction of the Vesica Piscis.



Oecus according to Vitruvius
(using a Vesica Piscis for the construction of the proportions)

6. Vesica piscis

Influence from the Roman World on S. Sofia

In examining S. Sofia, I have found evidence of Roman influence both in the initial planning of the building and in the construction techniques used to build it. It is clear that the church was built by masons thoroughly conversant with Roman construction technique. Evidence of this knowledge includes the coursing technique known as *opus mixtum*; the brick arch; the vault; and the single-shaft granite columns. Regarding the latter, the ability to move and erect single-shaft granite columns in a tight, complex pattern (such as that seen in S. Sofia) required that the builders use a Roman engine, the *polyspaston* described by Vitruvius (X.2) and de-

picted on a Roman funerary relief now in the Vatican Museums.²³

A suggestion has been made by M. Salmi that, in light of their familiarity with Roman construction methods, the builders of S. Sofia must have been brought south from Rome to work on the church.²⁴ This theory seems unnecessarily cumbersome. The survival of Roman building techniques in Benevento need not be explained by intervention from another quarter. Distinguished from other cities by its inheritance of Roman traditions, Benevento more than likely had a sizeable Roman population. After the initial invasions by Germanic peoples, the city soon saw the re-emergence (in somewhat modified form) of Roman law, language, distinct Latin writing scripts,²⁵ as well as music, the well known Beneventan chants, and other attributes of settled, ordered society – in short, a swift, all-encompassing stabilization that was not experienced equally by other parts of Italy or Europe. There is no reason to doubt that building techniques and skills would have been included among these enduring traditions.

The geometry found in S. Sofia is both classical and Christian. All of the geometric design elements seen in the church have a pre-Christian origin. To cite but one example, Vitruvius describes the proportions of the heights of an *oecus* as one and a half times the width, and the plan is a square. This translates into a diagram constructed with a *vesica piscis* (fig. 6), a geometric construction heavily freighted with Christian as well as pre-Christian meanings (it is used by various cultures

²³ A form of the *polyspaston* clearly survived through the Middle Ages, and may be seen, for example, in a painting by Pieter Bruegel, entitled *The Tower of Babel* (1563), where it lifts stone for the construction of a then very stylish Gothic tower; see also F. M. Barber, *The Mechanical Triumphs of the Ancient Egyptians*, London 1900, p. 47, fig. 10; L. Sprague de Camp, *The Ancient Engineers*, Norwalk/Conn. 1966, pl. 11; for the Roman relief (Tomb of the Haterii, dated to the early Trajanic period), see D. E. Kleiner, *Roman Sculpture*, New Haven 1992, p. 196–199, fig. 166.

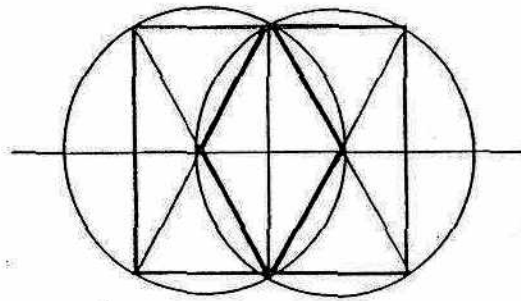
²⁴ Mario Salmi, «Maestri Comacini o Commacini?» undated photocopy in archives of Museo del Sannio, Centro Ricerche Bibliografiche: 409–424.

²⁵ E. A. Loew, *The Beneventan Script*, Oxford, 1914; Robert S. Hoyt, ed., *Life and Thought in the Early Middle Ages*, Minneapolis 1968, p. 23–29.

and faiths to signify the age of Pisces, a halo or aura-Mandorla, Isis, the Madonna, Jesus Christ, a general identification of Christianity, and more).²⁶ Leaving aside its symbolism, the *vesica piscis* exemplifies the time-honored way to construct a perpendicular and double-square rectangle (fig. 7). This rectangle of a 1:2 proportion also allows for the construction of root 2, root 3, and root 5 rectangles. Through geometric constructions the root rectangles may in turn be made into examples of the Golden Section, a special ratio to be found in both Euclid²⁷ and in Plato's *Timaeus*, an account of a 5th century BCE discussion with a Pythagorean on how the world is geometrically constructed.²⁸ The construction of a *vesica piscis* can directly develop into the Golden Section and the pentagon-pentagram actual symbols of the Pythagoreans (fig. 8). The double-triangle expression of the *vesica piscis*, used in the geometric planning of S. Sofia, is to be found through out Greco-Roman design. The same form of the *vesica piscis* survives in a wide range of ancient monuments, such as in the floor pattern in the Roman paving of the orchestra in the theater of Dionysos in Athens, and as the design for the pattern of numerous Roman stone-coffered ceilings, a fragment from one of which rests within a few feet of S. Sofia (fig. 9).

The Plan of S. Sofia: An Analysis

The designer of S. Sofia applied the geometry seen in the plan to create the three-dimensional form. Yet, since no single shape is shown in its entirety, the form only hints at the quantity of geometry seen in the plan – an effect which renders the true geometry hidden within the diagram. One cannot help wondering why the designer would mask the geometry intrinsic to its shapes. Of course that which is most valuable is most hidden, an ancient maxim recognized in Plutarch's essay on »What Plato meant by saying that God is always doing geometry:« he quotes Philolaus of Croton as naming geometry »the source and mother city of the rest.«²⁹ The church at Nocera, which the designer must have known, is about the same size as the later S. Sofia, but with a very clear circular plan. The apparently cobbled-together geometry we see in S. Sofia is satisfactorily explained only as the designer's intent, and suggests



7. *Vesica piscis demonstrated by half square diagonals*

that the shapes themselves held significance – for the designer, for the function of the building, or perhaps for some other, still unknown purpose.

Assuming that a geometric diagram was used to create the church's plan, I propose two solutions for its scheme of design based on symbolic geometry, which, alone or in combination, may be applied to S. Sofia. The solutions share the following characteristics:

- a) The eccentric forms in the plan can be explained by geometric diagrams.
- b) In both cases the diagrams show unconventional approaches to architectural design.
- c) The symbolic meaning of these diagrams may have sprung from an astrological or occult source.
- d) Both solutions require the addition of apses.

Below are summaries of the two solutions:

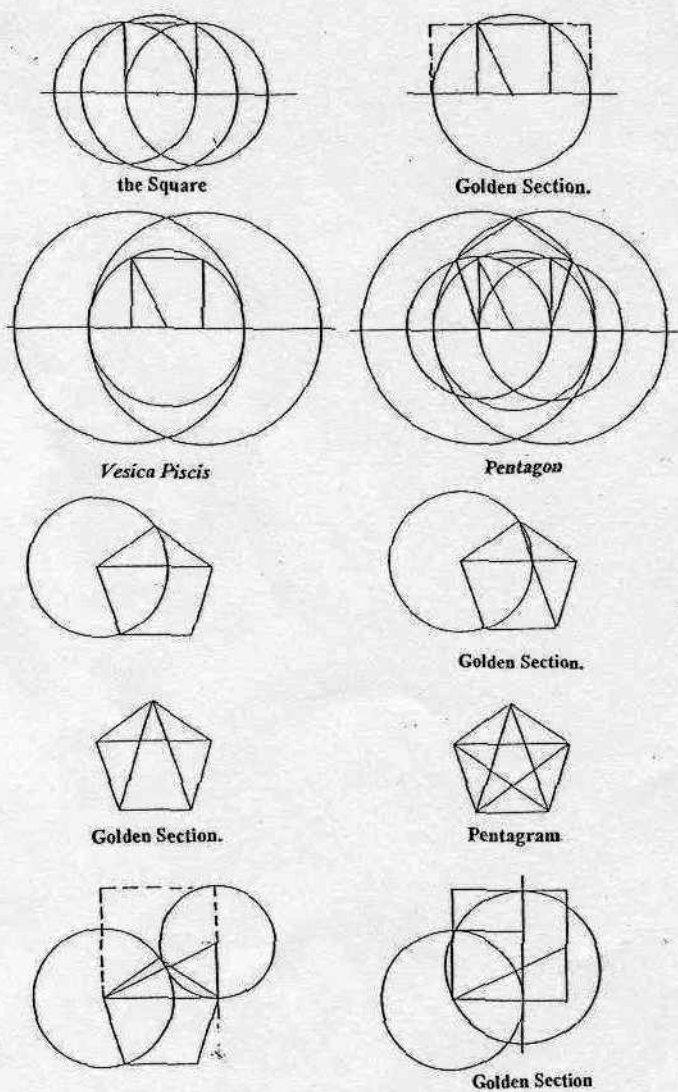
Solution 1: A simple geometric form has been altered in order to accommodate the axial foci, from entrance (West) to altar (East) required of a Catholic church. S. Sofia has an axis SW to NE.

²⁶ Sister M. A. Justina Knapp, O.S.B., *Christian Symbols and How to Use Them*, Milwaukee 1935, p. 43; D. H. Turner, Rachel Stockdale, Dom Philip Jebb, and David Rogers, *The Benedictines in Britain*, New York 1980, p. 53, ill. 34.

²⁷ Peter Kidson, A Metrological Investigation, in: *Journal of the Warburg and Courtauld Institutes* 53, 1990, p. 71–97; Matila Ghyka, *The Geometry of Art and Life*, New York 1946; Euclid, *Elements* IV.10, and II.11.

²⁸ Plato, *Timaeus*, trans. R. G. Bury, Loeb Classical Library (1952), esp. p. 58–61, 126–137 [32a–c; 53c–56c].

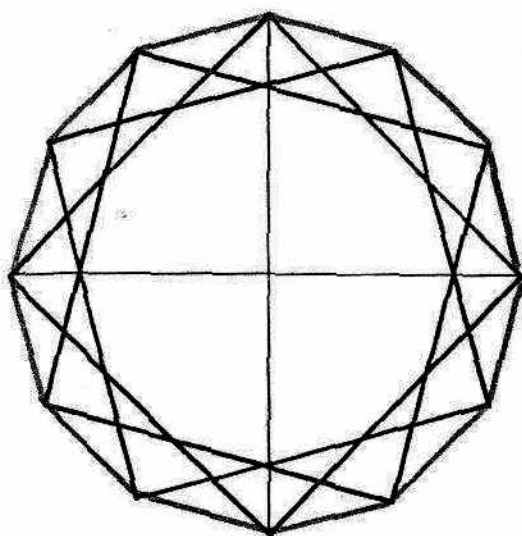
²⁹ Plutarch, *Moralia*, IX, Loeb Classical Library (1961), p. 118–131 [718c–720c].



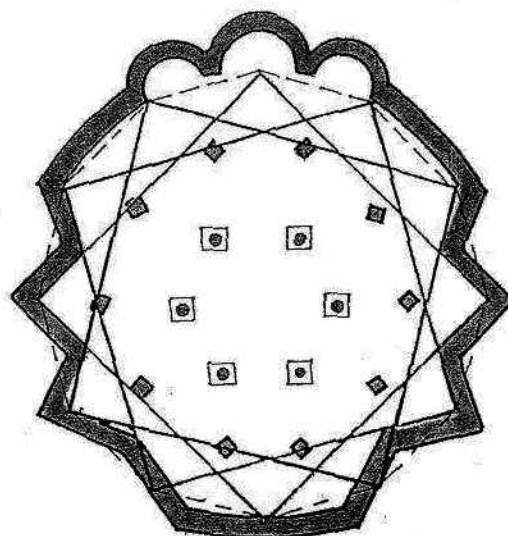
8. The graphic use of vesica piscis



9. Fragment of Roman architectural ornament next to S. Sofia (with a vesica piscis)



10. *The rotated square*



11. *The rotated square as a design diagram*

Solution 2: Four geometric symbols are superimposed, one over the next, and a design is then deliberately traced from fragments of each of the four diagrams.

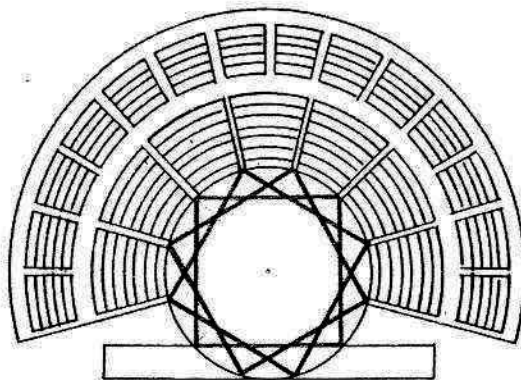
While the first solution accounts for only some of the ambiguities seen in the church plan, the second covers all of them. The motivation behind both solutions is mystical, expressed by intrinsically symbolic geometry. S. Sofia appears to represent a continuation of the flexible Roman geometric tradition, combined with an intentional and contemporary interpretation of the metaphysical world.

Solution 1

The church plan may be viewed as the result of a struggle to combine two conflicting ideas: a pure geometric form (in this case, a twelve-sided form) has been adapted to accommodate the directional axis generally required by Catholic ritual (fig. 10). The use of a rotated square (the doubling of the square) to create a twelve-sided figure would account for the unique triangular projections that interrupt the circular unity of the overall form (fig. 11). These projections from the circle are distinctive and important, as they show a singular, deliberate effort of formal expression, intended

to be read as such from both the exterior and the interior. The rotated square does not account for the pattern of the positions of the interior columns and piers, for the shape of the entrance (which is always located on axis opposite the altar), or the position of the three apses. Instead, the convergence of disparate elements must be explained as evidence of unpracticed and unlearned design: for some reason, the designer chose a rotated square to create a twelve-sided figure and, more to the point, wanted to incorporate the resulting elements in a formal expression. Therefore, in order to maintain the identity of the rotated square, the designer left the angles of four corners visible. To meet the desire for three apses, he reused the dominant curve as a transitional form and then added the entry. Two walls act as a funnel, leading from the narrow doorway of human scale to the wider interior, in order to meet the axial requirements of a church, where one sees the altar as a goal opposite the entrance.

With this explanation, the architectural application of a rotated square to produce this form remains unsatisfactory. After all, the designer might simply have followed the example of the church at Nocera and divided a circle into the desired number of parts like a pie. A difference here is that while most numbers can be re-



12. The rotated square as a design diagram in the design of Greek theaters

lated to some religious or mystical principle, and the building at Nocera is divided into fifteen parts, S. Sofia is heavy with strong religious and occult associations, with a division of twelve. This seems especially significant since the patron Duke Arichis II buried twelve saints inside S. Sofia, and there are many obvious correspondences with the number twelve.³⁰

Of the ten supports that form the outer ring eight are rectilinear piers of stone and brick; the ring is completed by two antique marble columns that flank the entrance axis, thus reinforcing the axis. The six central columns form a hexagon, with two dark columns, made of black marble, further flanking the axis of the church. Like all the groupings incorporated in the church, the hexad has many cultic associations.³¹

No matter how seemingly unskilled he may have been, the designer of S. Sofia was surely aware of the prevailing dictates of liturgical design for churches. The Catholic convention, intended to enhance Christian liturgy, was (and still is) a deliberately directional structure, with given foci, leading from the entrance to the altar. The design in S. Sofia with a definition of the necessary axis with flanking columns of different material and color would not be unique. The Longobard church of San Lorenzo, in Mantua, possibly built as early as 1078, in the form of a complete circle (following the precedent set by Nocera), also uses column materials to establish an axis. Here two white marble columns are placed in a ring of similar shaped brick col-

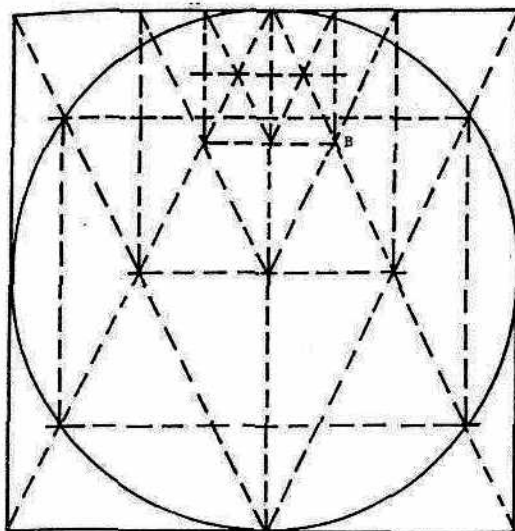
umns to flank the altar and define the axis. But the combination of the axial foci and the geometric shape seen in San Lorenzo results in a regular form (a complete circle) that is distinctly unburdened by the geometric oddities so readily apparent in S. Sofia.

With this explanation for its design (a rotated square), the placement of the interior supports in S. Sofia, arranged in two circles, then seemingly has a geometry of its own, with little direct relation to the twelve-sided shape of the exterior wall. Again, we would have to postulate that the columns and piers may have been repositioned within the interior, or that perhaps the discrepancy is just another sign of the limitations of the designer. The possibility remains that the designer copied the rotated square from Vitruvius's description (V.7) that shows how to locate the seating and scene in a Greek theater, for its location only, not to express form (fig. 12). In S. Sofia, however, the corners of the rotated square are clearly expressed both internally and externally.³²

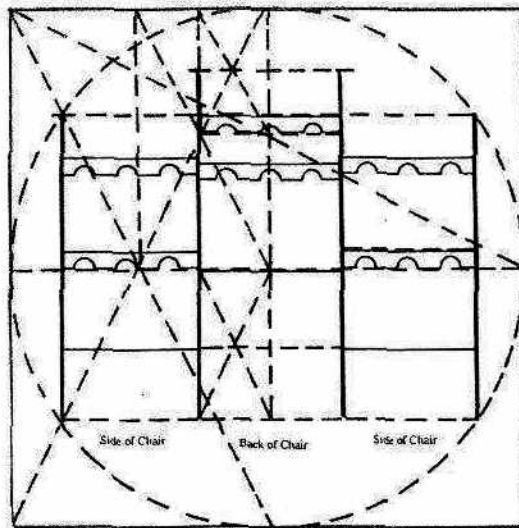
³⁰ Rusconi (as note 6).

³¹ W. Wynn Westcott, *Numbers*, New York 1911, 66. Further numerological exegesis may be found in Heinz Meyer, *Die Zahlenallegorese im Mittelalter*, [Munich, 1975], p. 74ff., and Franz Dornseif, *Das Alphabet in Mystik und Magie*, Leipzig 1922, p. 84, 85. Vitruvius himself undertakes numerological and cosmological exegesis on the moon in IX.1, thus indicating that architects in antiquity were aware of such symbolism.

³² In this context, it should be noted that two geometric elements were used in the process of design of ancient Greek theaters, for the location of the orchestra. The first is the previously mentioned rotated square, described by Vitruvius, which when placed over the orchestra plan is used to locate the aisles through the seating and up to the *scaena*. The second is interlocking two circles, one used to locate the front edge of the *scaena* and the curve of the seating, and the other to locate the performance area within the orchestra as defined by the first circle (cf. al Biruni [as note 9], p. 89, 97, 107). The circles are not concentric; instead, the centers of both are aligned on a common axis. For recent discussion of the planning of Greek theaters with geometry, Lutz Käppel, *Das Theater von Epidauros, die mathematische Grundidee des Gesamtentwurfs und ihr möglicher Sinn*, in: *Jahrbuch des Deutschen Archäologischen Instituts* 104, 1989, p. 83–106. The space formed between the furthest edges of the two circles takes the shape of a crescent moon, a symbol tied to Islam and the cult of Isis, which also figures prominently in the second design scheme proposed below for S. Sofia (Hans Wolf-



13. Controlling design diagram for the chair



14. Elevations of the back and sides of the chair superimposed on diagram 13

Solution 2

The geometric layout drawn by the designer and used as a guide by the builders may be worked out from the plan of the building. The *vesica piscis*, the Golden Section, the rotation of the square, the crescent moon, and the Shield of David are all readily identifiable when diagrams of the church are studied (see figs. 15–22). This combination of several forms is highly unusual. The traditional practice of using diagrams for the construction of buildings, furniture, etc., has not changed much throughout history, and typically a single diagram (fig. 13) is drawn to demonstrate the proportions and locations of the various parts of the subject (fig. 14).³³

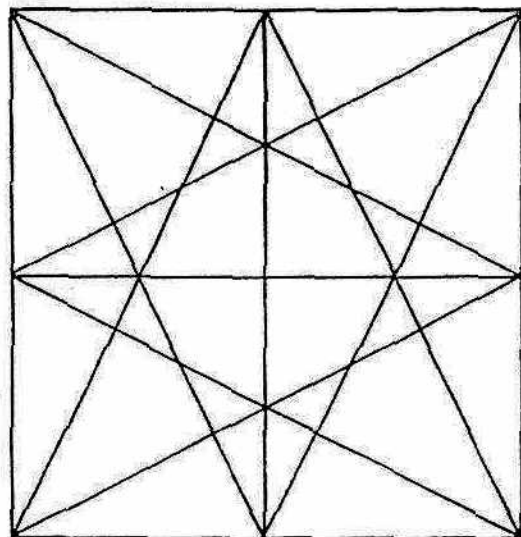
In contrast, the unconventional design of S. Sofia reveals the use of multiple diagrams of geometric symbols which have been superimposed on top of one another (fig. 21). The plan has then been picked out from fragments of each of the geometric symbols without using any in its entirety (fig. 22). The geometry of the plan is nearly hidden, or disguised. This procedure has a design analogy or parallel in the production of Persian and Caucasian carpets. While different periods in

the history of carpet-weaving exhibit distinctive styles, most share the design device of combining overlaid geometric symbols to produce stylized patterns.³⁴ Although the sequence of the layering may in fact be irrelevant to the plan, the choice of symbols seems laden with meaning, suggesting that the plan may have performed a special function, perhaps as an astrological

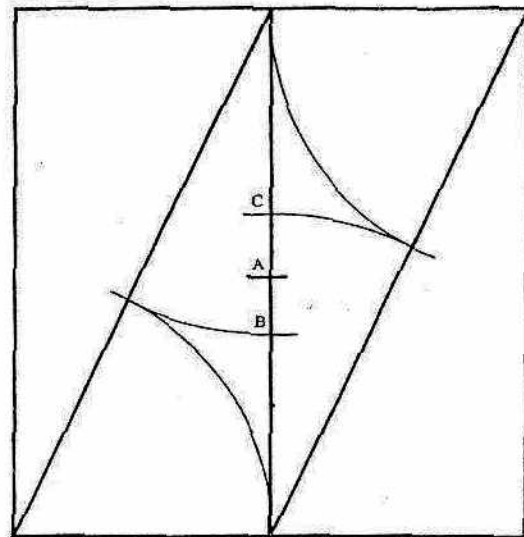
gang Muller, *Il culto di Iside nell'antica Benevento*, [Benevento 1971], p. 98, 99, and pl. 32.2).

³³ An example of this sort of orderly diagram is the drawing I have extrapolated from a seventh century chair stored in the crypt of the Cathedral of Benevento, near S. Sofia (fig. 14). The chair is bronze randomly studded with silver, featuring Saracenic technique but with strong Longobardic symbolism. The damascene decoration on the rails with the illustrations of two birds drinking from a bowl is a familiar Longobard motif which seems related to the *cantepleve*, or drinking bird mechanism, from the Middle Ages. The chair has elongated human feet. This curious mixture of classicism and naturalism is in keeping with the individualistic design we have seen in S. Sofia.

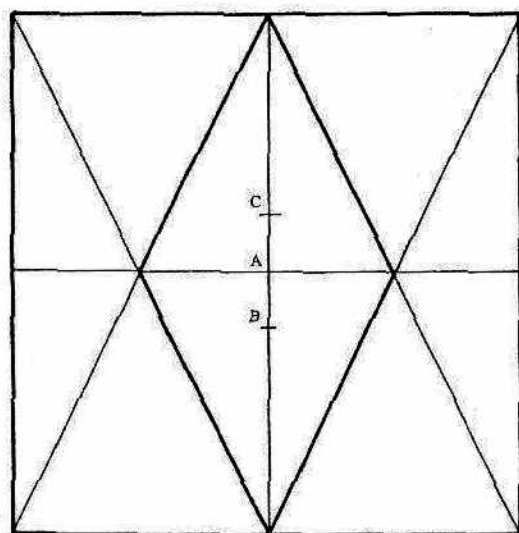
³⁴ Schuyler Cammann, *Symbolic Meanings in Oriental Rug Patterns*, in: *The Textile Museum Journal* 3, 1972 (1973), p. 24–29, 44–49; Nader Ardalan and Laleh Bakhtiar, *The Sense of Unity. The Sufi Tradition in Persian Architecture*, Chicago 1973, esp. p. 27–31, 33–45; Eva Baer, *Islamic Ornament*, New York 1998, p. 73–84.



15. Partial diagram for the plan of S. Sofia. Diagonals, half-squares, and vesica piscis



16. Partial diagram for the plan of S. Sofia, using the Golden Section

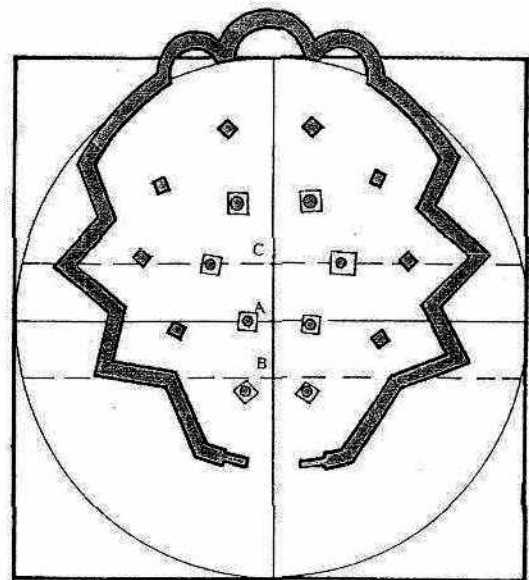
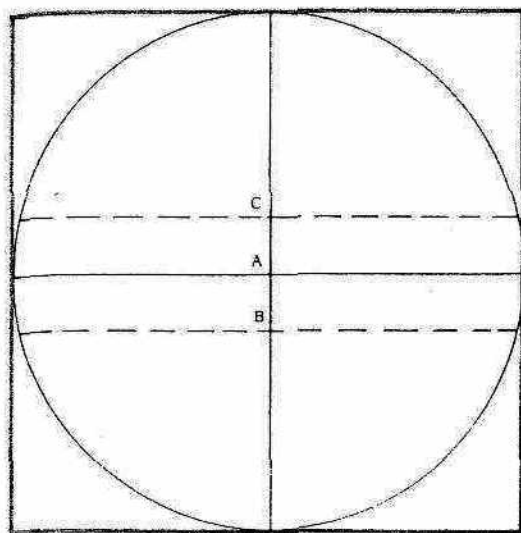


17. Three centers A, B and C, and a vertical vesica piscis

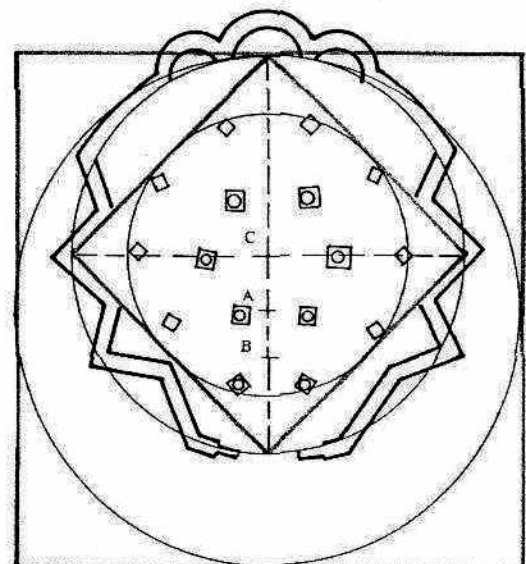
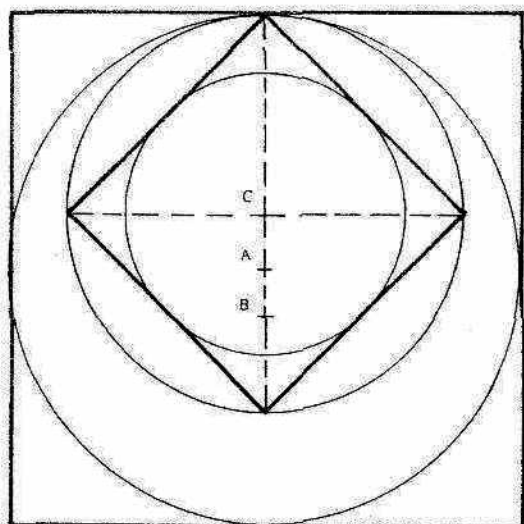
diagram. The intended meaning of the combination of symbols remains ambiguous, and it is not my intent here to speculate on all the possible hidden meanings

in the plan. Rather, it is the plan itself that requires explanation as an intriguing form of practical design. In my opinion, the most plausible explanation for the peculiarities of the plan of S. Sofia is that it contains a layering of familiar symbols connoting divine and cosmic protection, from which a single form has been extracted, and then manifested as a three-dimensional structure. In architecture, this particular design process has no known parallels.

If we apply the controlling diagram to a section of the existing building, we see immediately that the heights of the vaults and of the tower (as it appears today) are delineated by the diagram (fig. 23). This must have been one of the practical advantages of the design. It should be remembered, however, that the roof of S. Sofia has been re-built and the existing lantern over the central hexagon may not have been there in the original design. As an alternative, possibly the original form might have been similar to that of the church at Nocera, with the central area to be covered with a dome, but there are potential problems with using a hexagon as a base for a dome, and S. Sofia has not followed the church at Nocera in any other design principles. This suggests that the current form of the building is likely to have



18. The centers in a circle

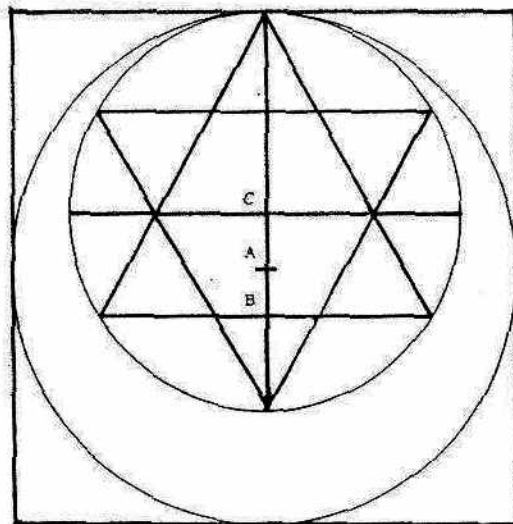


19. The rotated square within a circle within a crescent

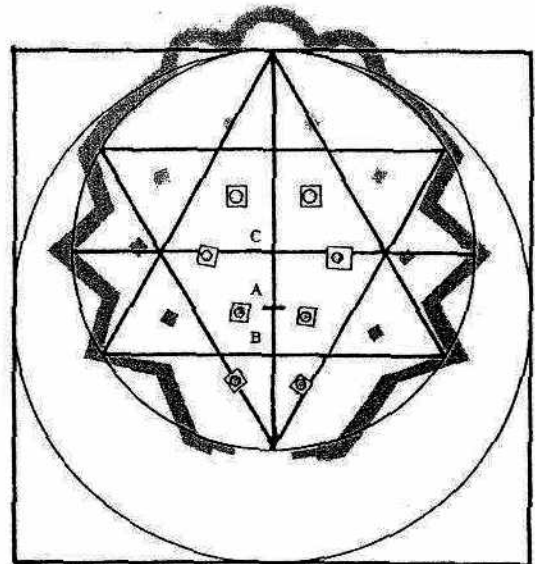
been closely similar to the original elevation, derived from the unusual plan.

The resulting spatial experience of the interior of S. Sofia is remarkable because it actually shares features

with the baroque style. A classical interior, as well as an early Renaissance interior, may be experienced from a single vantage point; it is the result of perspective drawing, and exemplifies the clear, controlled concept of



20. *Shield of David within a crescent*



space. A truly baroque space cannot be comprehended from a single point of view. Rather, the baroque interior must be experienced kinesthetically, requiring the individual to move through the space. This is the case with S. Sofia. But unlike the regular plans of structures built during the Baroque period, the 8th-century church is irregular.

In contrast to the churches at Nocera, San Lorenzo, and others based on complete, regular forms, S. Sofia offers a comprehensible idea (protection) in an incomprehensible space. The puzzling interior may have heightened the protection offered by each individual symbol. The occult aspects of the combination of symbols must have seemed freighted with meaning to those who perceived them. To safeguard their magic, the symbols have been unified in a design that acts as a protective disguise. S. Sofia can now be seen as a church designed to be a place of initiation: new beginnings, marriages, baptisms, funerals, or more. Thoroughly convinced of the geometry that underlies this church plan, I have analyzed the plan and recognized the following symbols in its configuration.

The actual sequence of figures used by the designer is unknown, as is the specific special significance attached

to each figure. Here I offer the symbols in the geometric sequence that seems likely to me. As shown on Figures 15 to 22, the process is as follows:

1: Fig. 15 – The first of four symbols is illustrated, a square.

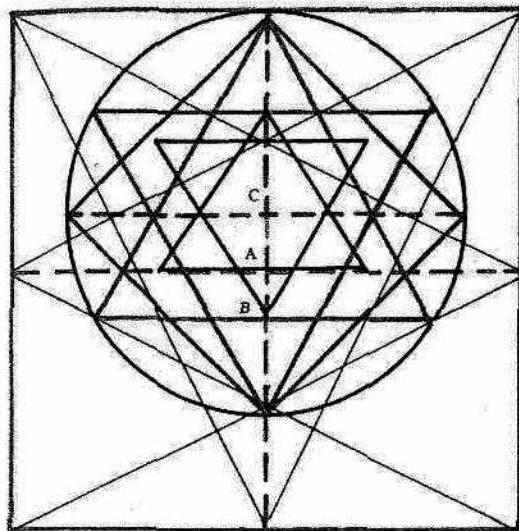
2: Fig. 16 – Then, using the Golden Section on each of the half-squares, we produce three centers on the central vertical axis of the original square. Here we are reminded of the construction of the plan of a Greek theater and the possible use of three centers.

3: Fig. 17 – The focus of this diagram is a vertical *vesica* with three centers. This designates the axis of the church. The *vesica* may symbolize the entry along this axis into the mystical world, as the 'spine' of the church.

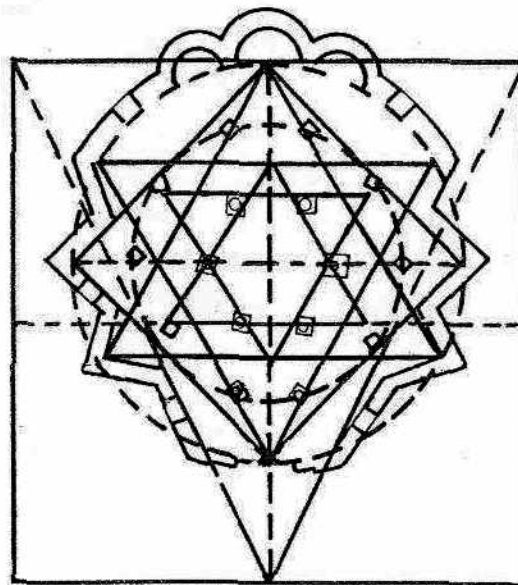
4: Fig. 18 – The second of four symbols, a circle contains three parallel, horizontal lines. This diagram is to be found in al-Biruni's handbook on the art of astrology.³⁵

5: Fig. 19 – The third of four symbols, the rotated square is inscribed within a circle within a crescent. A diagram in al-Biruni ([as note 9], p. 107[201]) shows

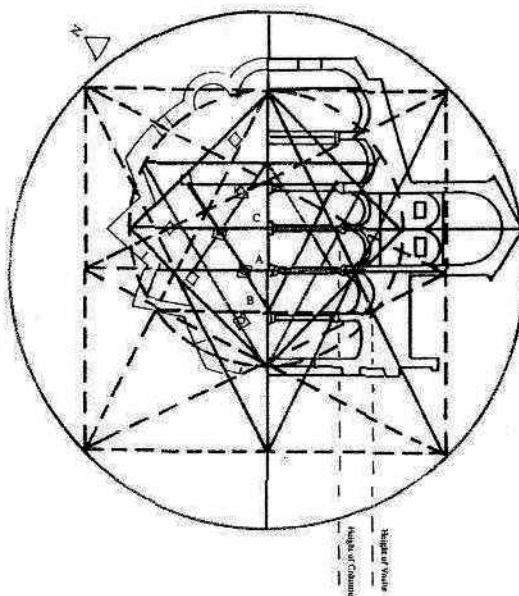
³⁵ al-Biruni (as note 9), p. 129 (220).



21. Complete diagram for the plan of S. Sofia



22. The complete design diagram superimposed on the plan of S. Sofia



23. Section and partial plan applied to the controlling diagram

two circles in the same relationship to each other. (This diagram is the same as that discussed previously, used to design the orchestra in a Greek theater.)

6: Fig. 20 – The fourth of four symbols, the six-pointed star or Shield of David is inscribed within a crescent moon.

7: Fig. 15 – The complete diagram for S. Sofia is illustrated. As with the designs of oriental carpets, the interwoven symbols have become apparently incomprehensible.

8: Fig. 22 – The layered diagram is illustrated superimposed on the existing plan of S. Sofia. This may be compared with diagram 12 with al-Biruni's diagram ([as note 9], p. 225[373]).³⁶

As a group, these geometrical diagrams correspond remarkably well to the actual plan of the church, including the position of the interior supports and the walls, given the known flexibility in design of the pe-

³⁶ There is a striking similarity between fig. 25 and a diagram in Franz Dornseiff's *Das Alphabet in Mystik und Magie*, Leipzig 1922, p. 85.

period, and the scope allowed individual masons for personal esthetic expression.³⁷ The plan of S. Sofia expresses a language of subtlety and sophistication, and its uniqueness invites speculation about its designer. Was the designer a maverick? The method used by his contemporaries and Roman predecessors was not one of layering geometric symbols one over another and then picking out a form. Rather, the typical designer used clear geometric constructions to form the plan, and although there were at times combinations of symbols incorporated into a single plan, the identity of the individual symbols is not obscure and can still be read clearly in the architectural plan. In contrast, the geometric structure on which S. Sofia's plan was based is not immediately apparent, but almost disguised. S. Sofia may have been a singular effort on the part of the designer: this one building, none before, none after. Perhaps he wanted to show all he knew in one building, or perhaps what we see is the hand of a master geometer rather than a mainstream architect, even though the techniques of construction are highly skilled for the period. In either case, the designer's considerable familiarity with geometry was applied to building design in a very unconventional way.

Designed by geometry, and replete with symbolism, the church of S. Sofia provides us with a window into a long-forgotten and hidden process of design. The two indisputable building blocks of the ancient world, geometry and its symbolic content, are continued here in the seventh century. But we are not simply examining a church; rather, there is a system of construction implied by the use of these tools. Classical features of architectural design, including the ubiquitous orders of architecture, are derived from a fundamental, geometric and symbolic system of commensurate parts. Puzzling and still potent, the church of S. Sofia provides a unique glimpse into this hidden world of ancient design and illustrates its enduring continuity.

Abstract

This paper examines the church of S. Sofia in Benevento (built ca. 760) and its unusual twelve-pointed plan as an exemplar of a geometric process of design used by architects in the early Medieval period. This simple and practical geometric process was inherited from antiquity and until recently was still used in Italy, a continuity assumed but not well documented. Although the upper parts of the church have been altered and repaired, the lower walls and most of the interior supports are original, as excavations of the 1950s have shown. For this study, a fresh examination of the church was made, including new measurements. An analysis based on traditional geometric design (in which the author was trained by an earlier generation of architects in Italy) shows that the unusual plan of the church is apparently deliberate and not the result of haphazard or 'provincial' building, as previous commentators have suggested. The historical context of the church, which was part of the palace-complex built by the Duke of Benevento Arichis II, included international contact with the Islamic world which influenced the complicated design, together with a continuation of the local Vitruvian legacy. Although distant parallels in Europe and elsewhere may be cited, the plan of S. Sofia provides a unique and complex example of a centrally-planned building replete with geometric oddities that probably had symbolic significance for the builders, at a time when such symbolism was felt to be a crucial part of design. This paper investigates the physical details of the design, the historical context of the church, the history of the process of design, and presents an analysis and solutions for its unique plan.

³⁷ William H. Goodyear, *Perspective Illusions in Medieval Italian Churches*, in: *Architectural Record* VI, 1896, p. 163-183.

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