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Unlocking Sinan's Architectural Language: Modular Design Through Geometric Recursion

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Abstract
This study investigates the possibility that Architect Sinan employed a recursive geometric modulation system—rooted in the use of the circle and the square—in the design of his architectural masterpieces. Through detailed proportional analyses of the Privy Chamber of Sultan Murad III and the Selimiye Mosque, the research explores how a series of circles correspond precisely to critical structural and spatial elements of the buildings. Following these two examples, the Haseki Hürrem Bath—one of Sinan's early works—was examined within the context of *ad quadratum* to further test the study's approach. The results reveal a design methodology so deliberate and consistent that it cannot be attributed to coincidence. These findings suggest that the recursive application of modular circles and squares may have served as a foundational design tool, guiding both the aesthetic and structural logic of Sinan's architecture. This research emphasizes geometric discipline over speculative symbolism, proposing that Sinan's mastery lay in a refined system of modulation.

Keywords Modular · Recursive · Ad quadratum · Architect sinan · Ottoman architecture · Euclid

Introduction

When we examine the extensive body of historical research on architectural works, a central point of contention emerges: to what extent can one truly reach the essence of architecture? (Schmarsow and Fiedler 2019, 52). Undoubtedly, the subjective nature of architecture—one that shifts according to the spirit of each era—plays a role in this complexity. The continuously evolving perception of buildings, shaped by those who create and interpret them, further complicates the pursuit of this essence. Therefore, the relationship between the architectural work and the intentionality it

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either embodies or surpasses has long been a subject of debate (Gregotti 2017, 106). Memory content and the sense of form develop in mutual correspondence. They move forward together, following one another. Neither allows the other to take a greater step (Göller 2019, 45).

Designers, architects, engineers, and specialized committees are known to have deliberated a wide array of questions concerning standardization (Rozhkovskaya 2020, 411). This preoccupation is not, in fact, exclusively modern. Fractal and repetitive potentials inherent in regular geometric shapes have inspired architectural creation since Antiquity. The irresistible allure of basic geometrical shapes and the ancient assurance they evoke are, in this context, unavoidable.

The angular nature of the square and the lack of angles in the circle are fundamental characteristics that distinguish them from one another. However, the fact that each can be derived from the other inevitably makes them the rationale for each other's existence, rendering them mutually dependent. Reconciling these two geometric archetypes has long been one of the most fundamental challenges in architecture. This paradoxical endeavor—one that first initiates a conflict and then seeks to resolve the resulting tension through various means—remains an ongoing pursuit. Accordingly, throughout the centuries, transforming a cubic space into a spherical dome has represented both a structural and a formal act of defiance. (Nasiri and Sarvdalir 2024, 177).

Instead of offering yet another addition to the ever-shifting and flighty perception of architecture—much like the nature of life itself—this study aims to contribute to an awareness of architecture's ancient relationship with geometry, through an analysis of two selected works by Architect Sinan. Serving under Suleiman the Magnificent, Selim II, and Murad III, Sinan held the position of Chief Imperial Architect of the Ottoman Empire from 1538 until his death in 1588. Widely recognized as one of the most distinguished figures in Turkish cultural history, Sinan's genius in merging art and technology has been the subject of extensive scholarship by both Turkish and international researchers. Yet, despite this wealth of research, much about Sinan and his architectural vision remains unexplored and unresolved. (Özdural 1998, 101).

In this study, one of Sinan's own self-descriptions has been selected as a lens through which to understand him—specifically, his relationship with geometry. The phrase "the Euclid of his age," found in his foundation text (vakfiye) (Necipoğlu 2017, 200), sparked curiosity and prompted an inquiry why he chose to liken himself in this way. Among the many laudatory expressions within his vakfiye, it is particularly noteworthy that only in this instance does he draw a parallel between himself and a historical figure. The fact that this comparison is made with a prominent mathematician from antiquity—whose name he uses almost as an epithet and from whom he seems to claim intellectual inspiration—renders the statement especially meaningful for anyone seeking to understand Architect Sinan on his own terms.

The present work primarily focuses on two of Sinan's creations from the later phase of his career: the Privy Chamber in Topkapı Palace and the Selimiye Mosque in Edirne. These structurally and functionally distinct buildings both feature distinctive circular elements—one prominent on the façade, the other in the plan—that serve as keyholes to unlock Sinan's design logic. Through recursive geometric analyses based on the collaboration of circle and square, findings reveal how these elements gradually delineate the spaces to which they belong. Finally, to validate the analytical approach applied to these two structures, another of Sinan's earlier works with a different function was examined within the ad quadratum framework, this time focusing on squares. The results reveal a design methodology so deliberate and consistent that it cannot be attributed to coincidence.

Prior to addressing the buildings and their analyses, the study will consider the historical sources of recursive approaches within the context of ad quadratum. Notably, the approach's major contribution lies in presenting a straightforward geometric analysis—accessible to anyone with fundamental knowledge of geometry—on three of Sinan's works, thus challenging the assumption that responses to complex problems must be complicated.

From Euclid to Sinan: Tracing the √2 Modulation in Architectural Design

The methods for constructing tangential relationships between the circle and the square were originally proposed by Euclid—the very figure with whom Architect Sinan compared himself. (Sertöz 2019: Euclid IV 6–9) For a regular polygon (i.e., a polygon with all sides and angles equal), it is always possible to construct both a circumcircle and an incircle. The square is a particularly simple example in this regard. (Heilbron 2000, 221) As illustrated in the manuscript of Villard de Honnecourt (Villard de Honnecourt, 1201–1300, pl. 20), various forms of square-based schematization that emerged in medieval architectural design can be summarized as follows: individual squares; planning grids composed of squares; and models consisting of nested and rotated squares within the system known as quadrature (Hiscock 2007, 181).

In the Islamic world, which inherited the drawing techniques of the Ancient World, it is understood that the proportional system was primarily based on the $1{:}\sqrt{2}$ ratio, derived through arcs drawn from the diagonals of squares. This system, which was universally employed in Islamic architecture, found its greatest advantage in the fact that its proportions were generated from the "perfect square"—a form that stood out for centuries as a favored shape throughout the Islamic world (Lewcock 1991, 131–132). In this architectural proposition, which begins with the construction of the building from the ground, the process starts with the square—symbolizing the physical form and the material world—a shape whose design is entirely dependent on the circle. The dynamic square, positioned diagonally within the static one, reveals a sequence of harmonic reductions that generate proportional relationships based on the $\sqrt{2}$ ratio. (Critchlow 1995, 28) The relationship between the two nested squares is defined by the fact that the side length of the larger (outer) square is $\sqrt{2}$ times that of the smaller (inner) square. As a result, the area of the outer square is precisely twice that of the inner square. (Özdural 2017, 192) The same geometric logic applies to the nested circles as well (Fig. 1).

The square is the most commonly used geometric figure, employed within linear grid systems, diagonal arrangements, or in quadrature systems composed

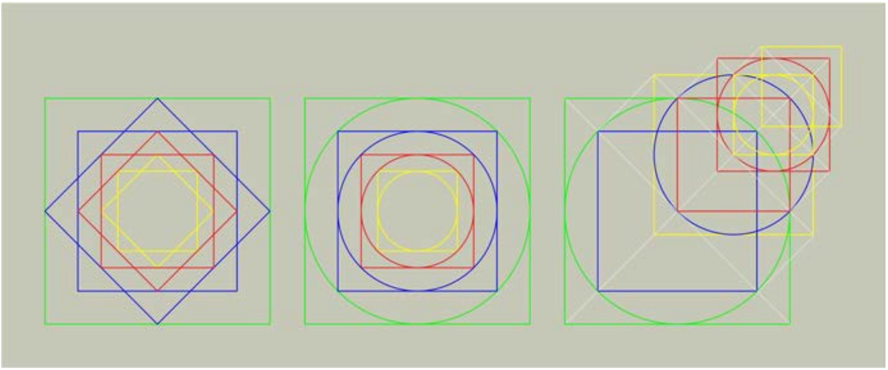

Fig. 1 Three versions of recursive application of modular circles and squares

of consecutively nested and rotated squares. These constructions are also added proportional relationships derived directly from the square, such as the $1{:}\sqrt{2}$ ratio formed by the square and its diagonal, and the $1{:}\sqrt{5}$ ratio associated with the double square and its diagonal. In most cases, this system is presented as a purely practical method, enabling the creation of geometric layouts using only a compass and straightedge—or, in the field, stakes, cords, and a set square. However, the precise expressive intent behind this system, or the reason it was preferred over other alternatives, remains unclear (Hiscock 2000, 6). As with many other studies on ad quadratum (Holme 2010; Lund 1921; Wu 2002), Bosman's design of the Pythagoras tree stands as a modern graphical expression of this approach (Bosman 1957).

Recent studies have shown that ad quadratum-based approaches provide valuable insights not only in terms of planimetric scaling but also in the calculation of architectural elements. For example, referencing the ancient mathematician Hero of Alexandria, the ad quadratum method—particularly associated with $\sqrt{2}$-based numerical progressions—has been examined in the context of Roman domed structures for its use of flexible and scalable geometric patterns (Roca et al. 2024). In another study, a comparative analysis was conducted between the mathematical and geometric principles used in the design of Hagia Sophia and a complex geometric design carved in stone at the Galerius Complex in Thessaloniki (Savvides 2024).

A Comparative Study of the Privy Chamber of Sultan Murad III and the Selimiye Mosque

The geometric secrets behind the master architect's unique designs, which seem to allow no alternatives, have attracted the attention of many researchers. However, like other imperial Ottoman court architects before and after him, Architect Sinan left no written records detailing his geometric design methodology and principles. As a result, his works have been analyzed deductively by scholars, an approach that has depended largely on the quality and quantity of available architectural surveys. Numerous valuable studies have focused on analytically examining Architect Sinan's design approaches and understanding the proportions he employed (Arpat

1984; Burelli and Gennaro 2008; Cantay 1986; Kuran 1973; Özyalvaç 2025; Parisi 2008; Söylemezoğlu 1981). Among these, Söylemezoğlu examined the Selimiye Mosque—one of the subjects of our study—through quadrature applied to schematic plans, and sections; however, this work did not go beyond a general preliminary assessment. The Selimiye Mosque, also studied by Burelli and Gennaro, has been approached not through comprehensive geometric analysis but rather with an emphasis on modulation, expressed through artistically rendered graphic representations (Burelli and Gennaro 2008).

The Privy Chamber of Sultan Murad III

The construction of the Privy Chamber of Sultan Murad III was completed in 1578, following the inauguration of the Selimiye Mosque in Edirne for worship in 1575. Commissioned by Sultan Murad III, the chamber was built in the Harem section of Topkapı Palace, situated between the Courtyard of the Valide Sultan and the Courtyard of the Imperial Consorts (İkballer). The audience hall of the pavilion underwent alterations during subsequent additions (Eldem)(Figs. 2 and 3). Today, it is located between later structures such as the Imperial Sofa (Hünkar Sofası), Veliaht's (Heir's) Appartments (Çifte Kasırlar), the Library of Sultan Ahmed I, and the Fruit Room of Ahmed III.

Despite the architectural evolution around it, the pavilion has largely retained its original character and was considered one of the most magnificent

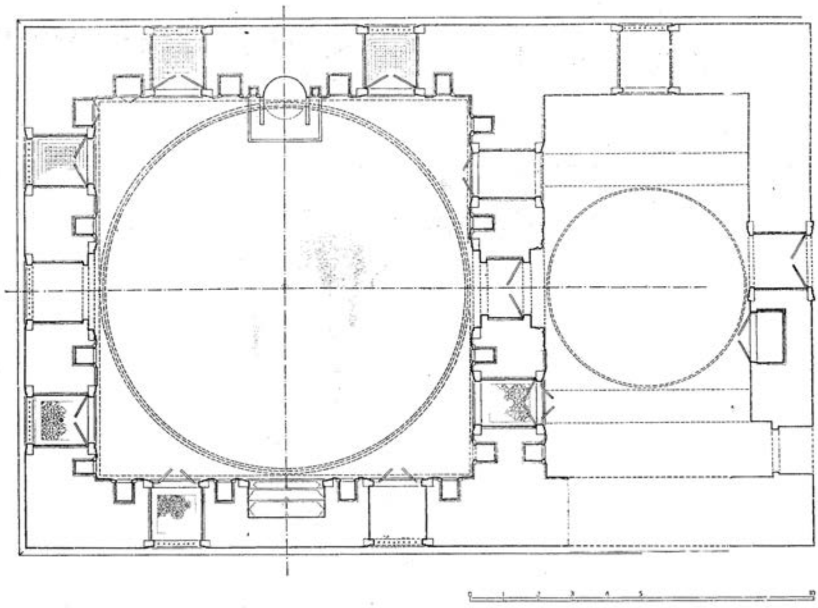

Fig. 2 Reconstruciton plan and façade of the Privy Chamber of Sultan Murad III (Eldem)

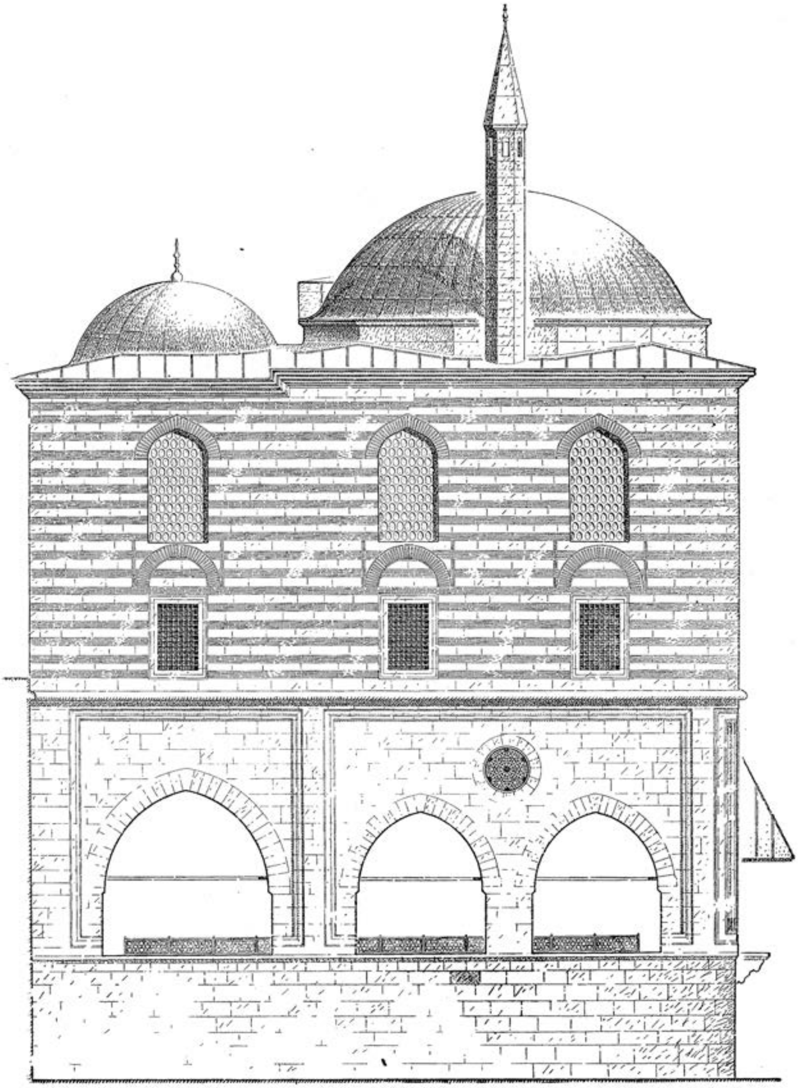

Fig. 3 Reconstruciton plan and façade of the Privy Chamber of Sultan Murad III (Eldem)

and significant buildings among the palace structures of its time. Constructed of masonry with a square plan, the main chamber is covered by a single dome, resting on a groin vault that rises above a pool located in the basement level. The most influential architectural element of the Privy Chamber of Murad III that inspired this study is the circular perforated stone feature on its façade (Figs. 4 and 5).

Fig. 4 Current façade of the Privy Chamber of Sultan Murad III

Fig. 5 Circular perforated stone colored

The Selimiye Mosque

Architect Sinan successfully applied his concepts of creative design in the mosques he built for a wide spectrum of patrons, including three sultans and their entourages (Necipoğlu 2017, 134). Throughout his remarkably long and productive career, he consistently avoided repetition, always opting to explore new architectural forms. In the Selimiye Mosque in Edirne, rather than reinterpret the plan of Hagia Sophia with which he was in direct dialogue, Sinan aimed to create a global masterpiece by employing a centrally planned octagonal baldachin—a distinct departure from the square baldachin schemes he had used in earlier imperial mosques.

In Selimiye, whose dome slightly surpasses that of Hagia Sophia in diameter, Sinan abandons the pyramidal hierarchy of domes and semi-domes characteristic of his classical style. In doing so, with Selimiye, he breaks from his own classical conventions and initiates a new architectural paradigm (Necipoğlu 2017, 133). Completed and opened for worship in 1575, the Selimiye Mosque is a masterpiece that defines the unique qualities of Ottoman architecture and its distinguished place within the history of world architecture. (Kuban 2021, 295) Undoubtedly, the most significant feature of the mosque is its monumental dome, supported by eight piers, which spans and unifies the central prayer hall beneath it.

Methods

When examining the common ground between the deductive and inductive methods frequently used in architectural research, it becomes apparent that the module functions as a goal in the former and as a tool in the latter (Berkin and Civelek 2019, 3). Since the requirement for data to be as objective as possible and the requirement for knowledge to be as meaningful as possible are inherently incompatible, a latent conflict continues to persist between them. The simultaneous existence of the three phases commonly associated with architectural surveying—measuring, drawing, and knowing—constitutes the only framework capable of reconciling both the objectivity of scientific evidence and the theoretical acceptance of dimension, as well as legitimizing the inherent subjectivity of the researcher's initial investigative impulse (Belardi 2018, 9–11).

Whether approached through induction or deduction, geometric analysis studies in architecture—when based on the building itself as the primary source—require architectural surveys that are as accurately measured and internally consistent as possible. Measurement deviations resulting from the original construction or from later structural deformations, potential errors in survey data—even when obtained digitally—or the prescriptive rigidity of theoretical equations can render geometric analysis problematic. Since geometry in Ottoman architecture functions as a fundamental design tool far beyond mere ornamental motifs (Özyalvaç 2025), the quality of architectural documentation directly influences the credibility and interpretive reliability of architectural geometric analyses. For this reason, the geometric analyses in this study have been conducted based on the most recent architectural surveys prepared under the supervision of the Ministry of Culture and Tourism. But, although these data are based on the most recent available documentation, the possibility of measurement errors cannot be entirely ruled out.

The most prominent feature of the most visible façade of the Privy Chamber of Sultan Murad III, located within the Harem, is a circular stone element carved with a geometric star motif, positioned between twin arches that rise above the basement level. This monolithic circular stone, perforated with a six-lobed geometric lattice pattern, is framed by a single ring of stone masonry. With its solitary presence on an otherwise solid and massive stone wall, this distinctive element evokes the visual impact of a Gothic rose window. The presence of such a circular motif—uncommon in classical Ottoman façade architecture—on the most exposed elevation of the most private structure designed for the sultan within the Topkapı Palace Harem suggests the possibility of a symbolic signature of the architect. This singular feature appears to function as more than a mere architectural element, potentially conveying a deliberate message beyond its formal or structural role. Measurements taken from the architectural survey further revealed a proportional relationship between the inner perforated circle and the surrounding solid ring, demonstrating a ratio of $1{:}\sqrt{2}$—an indication of intentional geometric design.

This observation suggests that Sinan may have deliberately concealed a design secret in the most visible part of the structure. Alternatively, it may be that this scheme—perhaps widely recognized in its own time but later forgotten—has evolved into a "secret" over time and now seeks to be rediscovered. Regardless of the reason, these two concentric circles have been deemed worthy of being treated as a design module in the analytical investigation of the Privy Chamber. Considered the core of a recursive pattern, this module—based on $\sqrt{2}$ progressions—was found to inform the dimensions of various architectural elements, from parts to whole, including wall and dome measurements. Despite its simplicity, this method yielded surprisingly consistent and convincing results. As such, it was tested again in Sinan's most ambitious and recently completed work, the Selimiye Mosque, whose massive central dome rests on arches supported by eight columns. Each of these eight columns—except for the two that merge into the outer walls in the direction of the mihrab—have a dodecagonal plan. Given their near-circular forms, each of these columns was found to be a source of inspiration for the recursive approach used in the geometric analysis of the Selimiye Mosque. The method once again yielded coherent results, which were demonstrated in both plan and section drawings. Although the *arşın* or *zîra*, the Ottoman unit of measurement, varied across regions and periods, it is estimated that during the last quarter of the sixteenth century, it measured approximately 73.4 cm (Özdural 1998, 106). The architectural elements that inspired this research were also analyzed according to this unit of measurement. However, what is crucial here is the finding that, regardless of the exact unit, the repetition of a core module determined the dimensions of other architectural components in both buildings—from part to whole, from small to large.

Within the scope of this research, the modulations, each specifically devised for the selected structures, were tested against the measured dimensions on the surveyed plans. Selected deviations between the modulation-proposed dimensions and the actual measurements were quantified as percentages and annotated directly on the drawings. Examination of these minor discrepancies, alongside the accompanying graphical representations, allows for a clearer assessment of the methodology's consistency and objectivity.

Results for the Privy Chamber of Sultan Murad III

The integrated geometric perception of the circular element on the façade of the Privy Chamber of Murad III and the surrounding ring has functioned almost as a keyhole for the geometric analysis of the structure. Indeed, the way the second circle emerges through the reiteration of the first one reveals a deliberate relationship between the diameters of the two elements. Although the diameter of the the first circle ($C1 = 171$ cm) is not a whole-number multiple of the arşın (73.4 cm), but rather 2 1/3 arşın, subsequent stages of the analysis—both in plan and section—demonstrated how this initial module evolves through repetition into a full-number multiple of the arşın. The recursive process demonstrated that each iteration corresponded to a mindful dimension with respect to structural, architectural, and decorative aspects (Table 1 and Figs. 5, 6 and 7).

As previously noted, the first circle that served as the basis for the recursive geometry was not a whole-number multiple of the arşın. However, this did not

Table 1 Moduls with their equivalents and correspondences on the Privy Chamber of Sultan Murad III

MODUL	EQUIVALENT	CORRESPONDENCE
CO		• Diameter of the oven • Depth of the oven's base • Depth of the fountain niche • Width of the windows • Height of the pool's fountain
C1	**Modul**	• Diameter of the circular carved motif • 1/6th of the chimney • Width of the exterior top windows • Width of the middle pier between twin arches
C2	2 x C0	• Circular stone bond surrounding the modul C1 • Width of the oven's base • Width of the fountain niche • Height of the windows
C3	2 x C1	• Plan of the berms • Height of the exterior top windows • Impost height of the twin pointed arches
C4	2 x C2	• Arc of the pointed twin arches
C5	2 x C3	• Length of the outer wall's contour to the main pier
C6	2 x C4	• Height of the ground floor • Height of the arch in the main floor
C7	2 x C5	• Exterior contour of the dome's section
C8		• Inner contours of the champer's plan • Diameter of the dome's gallery
C9	9 x C1 *≈21 arşın*	• Outer contours of the chamber's plan

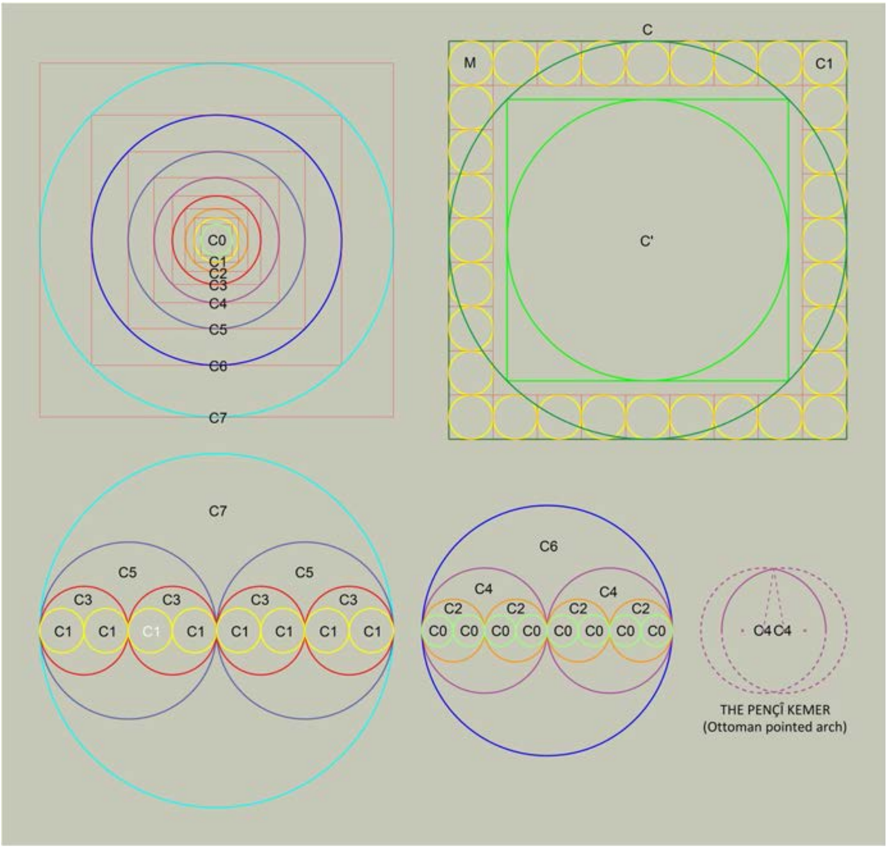

Fig. 6 Scheme of the recursive modular circles and the modulation of the Privy Chamber within the plan (The Pençî Kemer known as Ottoman pointed arch (Özyalvaç 2020a, b))

prevent it—along with the square tangent to its outer edge (M)—from serving as the modular unit for both the plan and the section of the Privy Chamber of Murad III. When this module was applied to the square plan of the chamber, it was revealed that one side of the square space corresponded precisely to nine modules. The total length of these nine modules ($9 \times 171 = 1.539$ cm), when divided by the length of one arşın ($1.539 / 73.4 \approx 21$), showed that each side of the square plan measured 21 arşın. Based on the current outer dimensions of the square plan, a reverse iteration revealed that the inner spatial boundaries of the structure, as well as—circularly—the diameter of the dome's gallery opening (C′), could be derived from this same modul. The height of the chimney also corresponded to the total length of the six modules.

Returning to the beginning of the analytical study, it becomes evident that the circular element on the façade—the origin of the recursive pattern—and its surrounding ring, when translated into a square version, not only define the building's plan but also establish the primary unit governing the 1:1 modulation

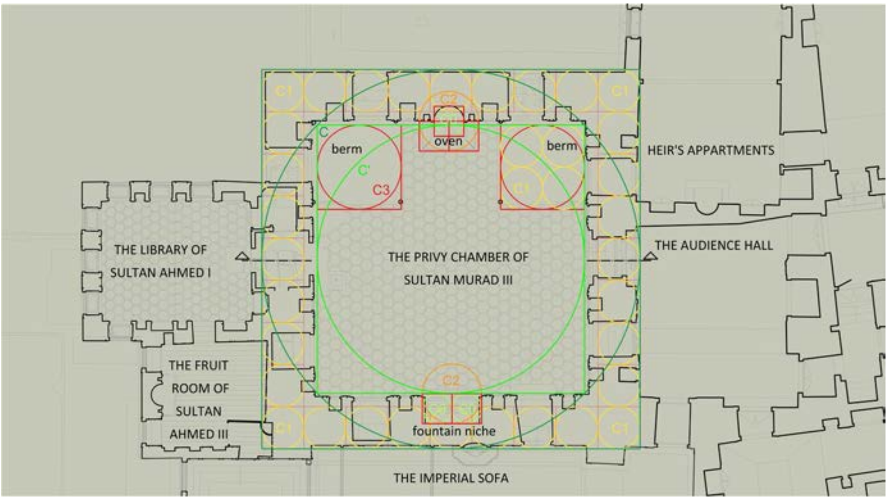

Fig. 7 Analysis of the main plan of the Privy Chamber

of the entire structure. The consistency of this modulation is also observed in the vertical dimension, from the basement floor level up to the dome drum, which measures exactly 12 modules, or 28 arşın in total. The structure's proportions—21 arşın in width and 28 arşın in height—reveal a deliberate design choice, as they produce a ratio of 3:4. Notably, these dimensions align with the classical Pythagorean triangle ratio of 3:4:5, suggesting an intentional geometric order underlying the building's design (Figs. 3, 4, 5, 6, 7, 8, 9, 10 and 11).

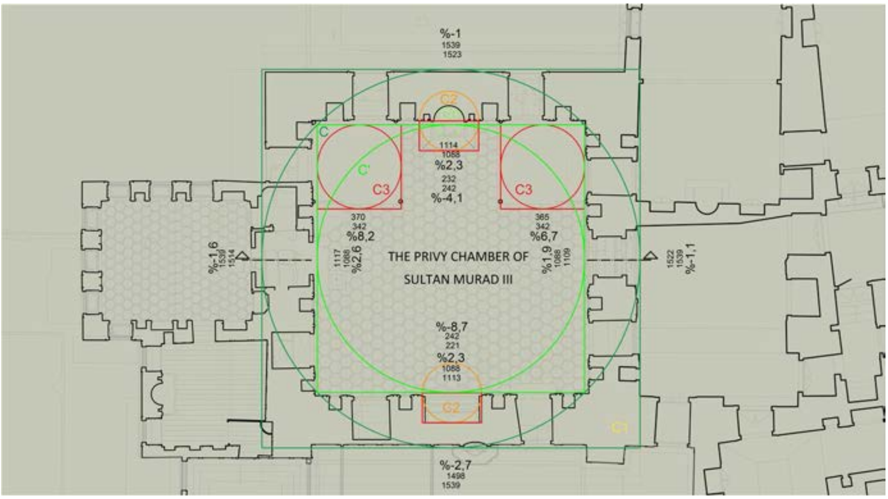

Fig. 8 Selected dimensions and their deviations annotated on the plan

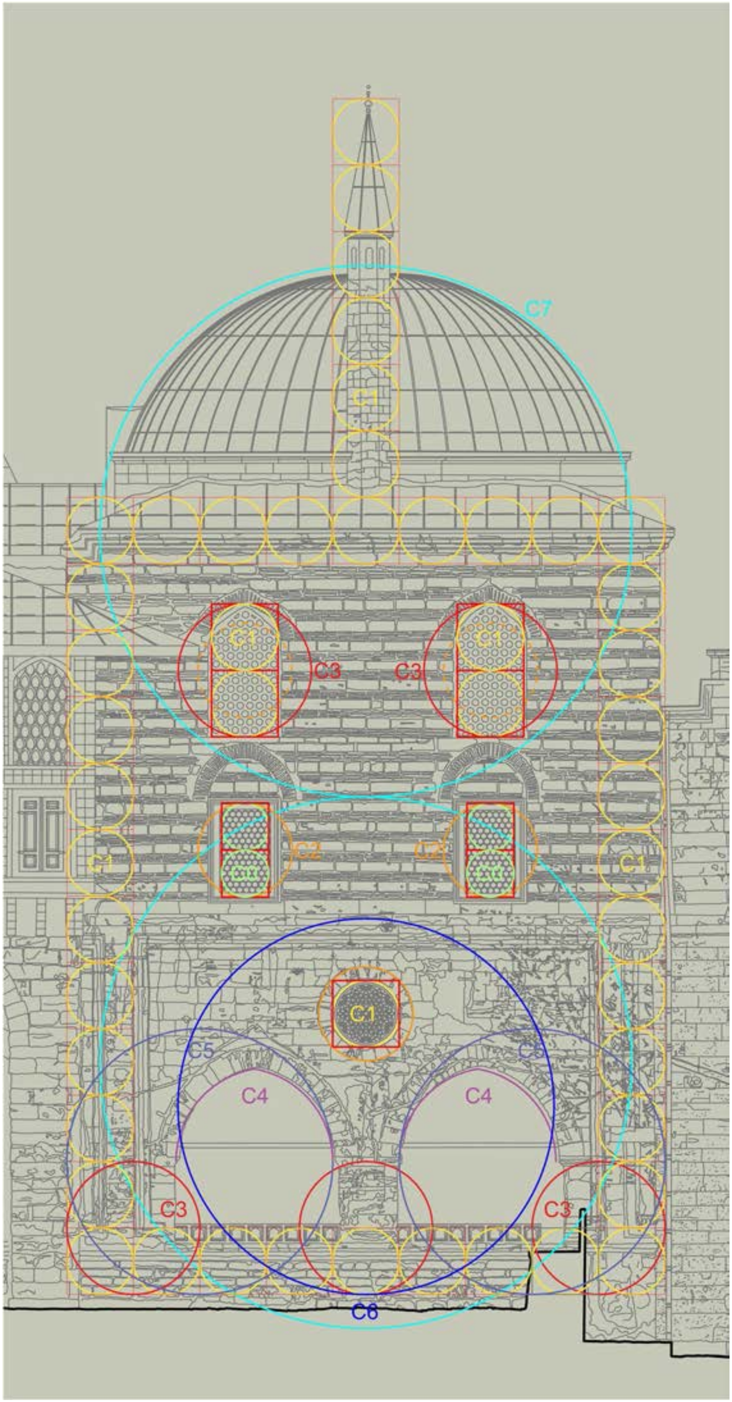

Fig. 9 Analysis of the façade

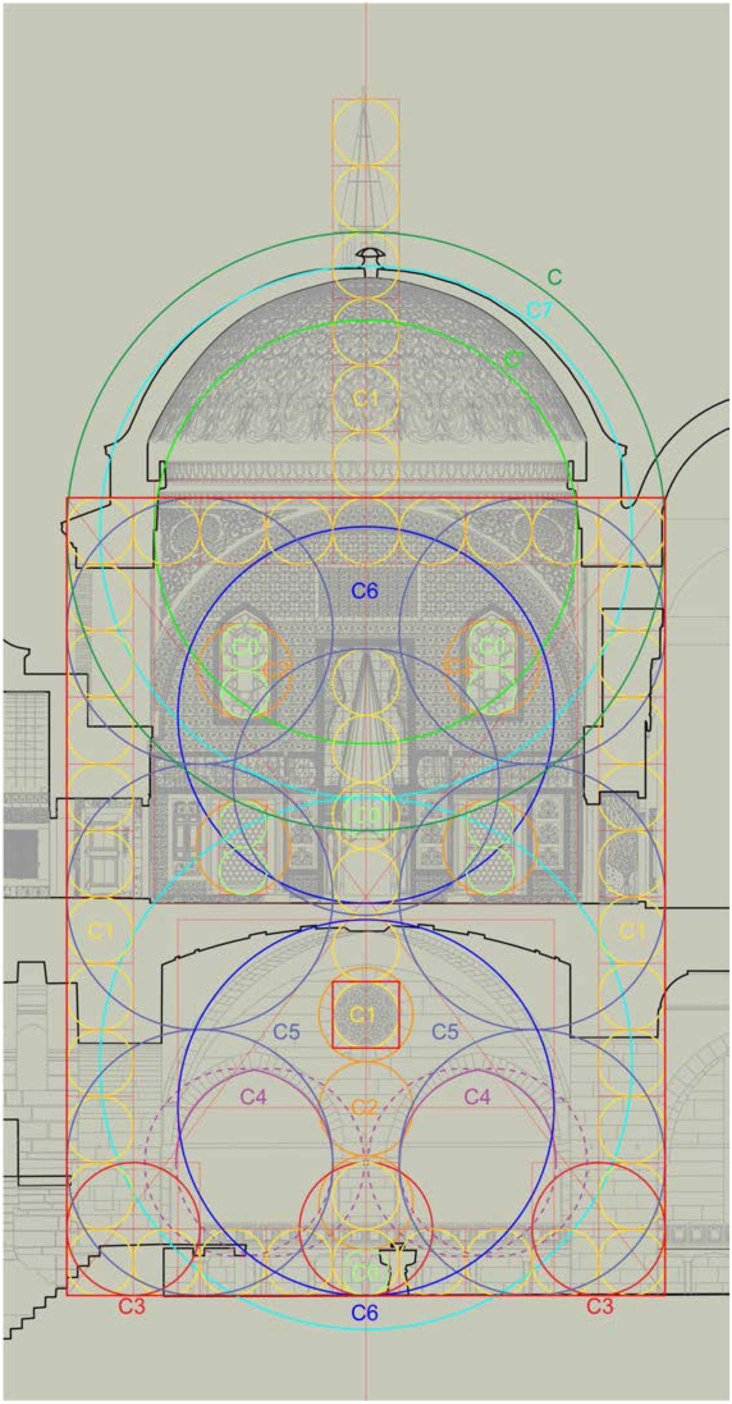

Fig. 10 Analysis of the section

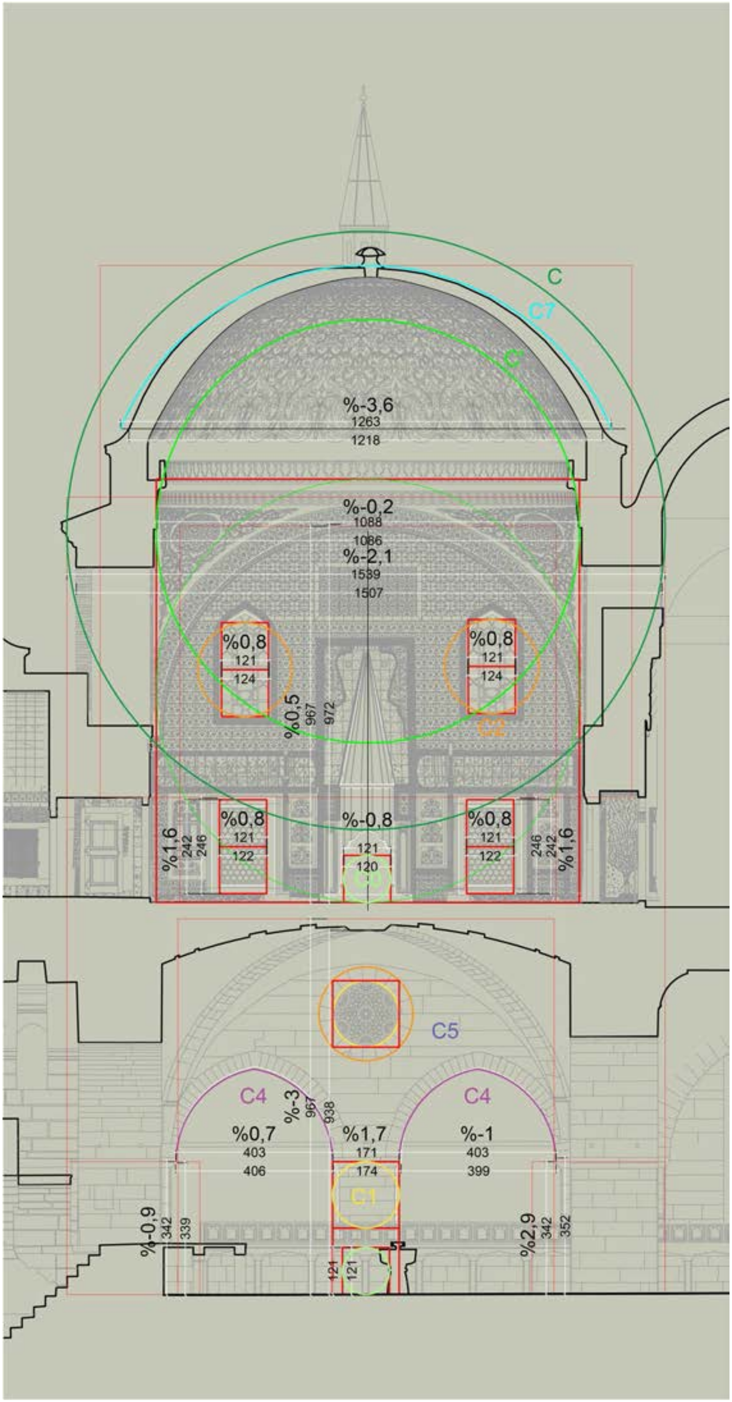

Fig. 11 Selected dimensions and their deviations annotated on the section

Results for the Selimiye Mosque

The previous analysis, which revealed correspondences too consistent to be attributed to coincidence, necessitated validation through a different structure. For this purpose, Architect Sinan's masterpiece—the Selimiye Mosque in Edirne, completed a few years prior to the Imperial Chamber of Sultan Murad III—was selected. When the diameter of the circle inscribed tangentially within the dodecagonal plan of the piers supporting the main dome was measured, it was found to be 367 cm, corresponding to 5 arşın (73.4 cm × 5).

Upon recognizing that the diameter of the structure's primary load-bearing element was an exact multiple of the historical unit of measurement, the implications of this dimension within a recursive design framework were further investigated. However, before proceeding with subsequent iterations of the circle, a sectional analysis revealed that the height of the piers was five times their diameter. It was further observed that three diameters corresponded to the height up to the profiled portion of the main pier, while the remaining two diameters extended to the springing of the main arch.

Significantly, the diameter of the pier also matched that of the minaret shafts. As such, the diameter of this key structural element—selected for the Selimiye Mosque—was adopted as a foundational unit, serving as the initial module (C1) from which the remaining dimensions of the structure could be derived through recursive analysis. In the last stage of the recursion (C9 = 16 × C1), the outermost boundary of the structure was reached—corresponding to a total of 80 arşın. Finally, a retrospective analysis was also conducted specifically for this structure. In plan, a circle (C′ = C8 – [2 × C1]), inscribed tangentially to the eight piers supporting the main dome, was found to correspond in section to a circle that externally envelops the profile of the main dome (Table 2, Figs. 12, 13, 14, 15 and 16). The findings indicate that each of the recursive stages produced circular modules that played a determinative role in shaping both the plan and the section of the Selimiye Mosque such like the Privy Chamber of Murad III.

A Final Verification through the Analysis of the Haseki Hürrem Bath

Approximately two decades prior to the construction of the two aforementioned structures, in 1555/1556, Architect Sinan designed the Haseki Hürrem Sultan Bath for the legally wedded wife of Sultan Suleiman the Magnificent. Located opposite Hagia Sophia in Istanbul, this building functions as a double bath, serving both men and women simultaneously, and is organized according to a symmetrical plan scheme. The spatial arrangement is predominantly determined by four large square units of equal size, aligned side by side, whose exterior wall lengths correspond to 22 arşın (22 × 73,4 cm = 16,15 m) as measured on the plan.

In this case, unlike the analyses above, the approach proceeds deductively from the largest square module—defined as S8 with a side length of 22 arşın—toward progressively smaller square modules. In the *ad quadratum* recursions, all of the

Table 2 Moduls with their equivalents and correspondences on the Selimiye Mosque

MODUL	EQUIVALENT	CORRESPONDENCE
Cc		• Width of the dome gallery's consule • Width of the top windows • Width and height of the side top windows
Cb		• Width of the top windows • Height of the top windows • Width and height of the gallery's folding screens • Height of the calligraphic frieze
Ca	2 x Cc	• Frame border of the interior pool • Diameter of the staircase of the muezzin's platform • Height of the top windows • Width of the top windows • Width of the doors
CO	2 x Cb	• Height of the top windows • Width of the doors • Arc of the pointed arches
C1	**Modul** 2 x Ca *5 arşın*	• Diameter of the main piers • 1/5th of the main piers' height • Diameter of the minarets • Width of the main entrance • Depth of the arcades in both sides of the mihrab • Width of the main dome's tambour • Height of the main dome's windows • Arc of the pointed arches
C2	2 x C0	• Radius of the semi-domes
C3	2 x C1	• Diameter of the minarets' bases • Height of the main dome's alem • Inner diameter of the domes surrounding the court
C4	2 x C2	• Diameter of the semi-domes • Arc of the pointed arches
C5	2 x C3	• Height of the main dome • Arc of the mihrab semi-dome's section • Height of the court's arcades
C6	2 x C4	• Height of the main entrance arcade
C7	2 x C5	• Diameter of the main dome's gallery
C'	C8 - (2 x C1)	• Exterior contour of the main dome's section
C8	2 x C6	• External tangent to eight main piers • Height from the apex of the main dome down to the top of pool in the center • Width of the court
C9	16 x C1, 2 x C7 *80 arşın*	• Tangential to the borders of interior space on sides • Tangential to the borders of the court on sides

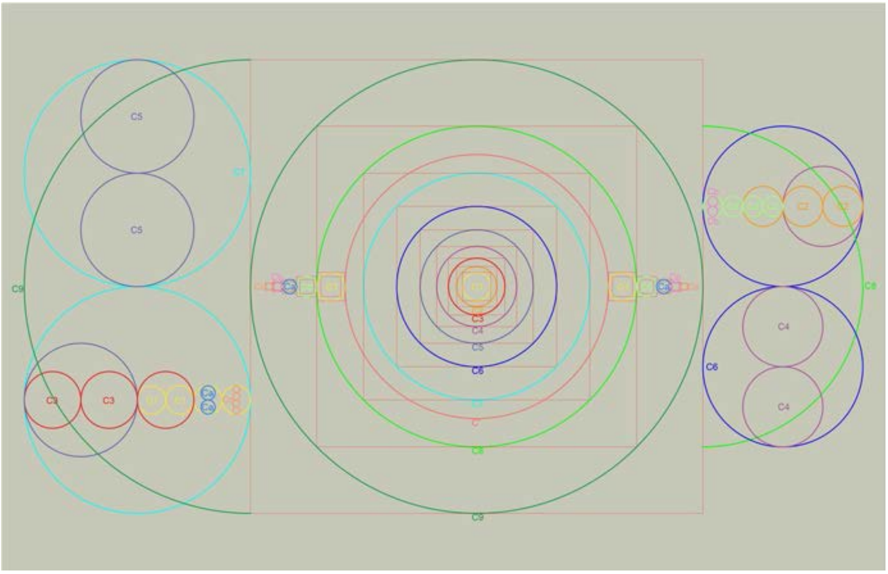

Fig. 12 Scheme of the recursive modular circles

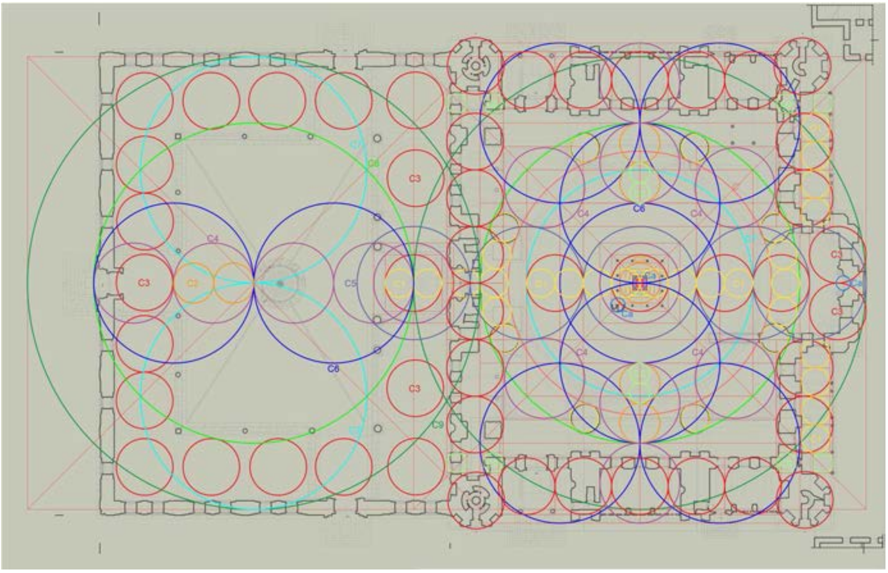

Fig. 13 Analysis of the plan of the Selimiye Mosque

generated modules were again found to play a decisive role in determining the dimensions of the spaces. It is also quite striking that the modul 1 (S1), which was decisive in the other examples as well, corresponds here to the wall thickness of the frigidariums. Similar to the recursive circles mentioned above, the square

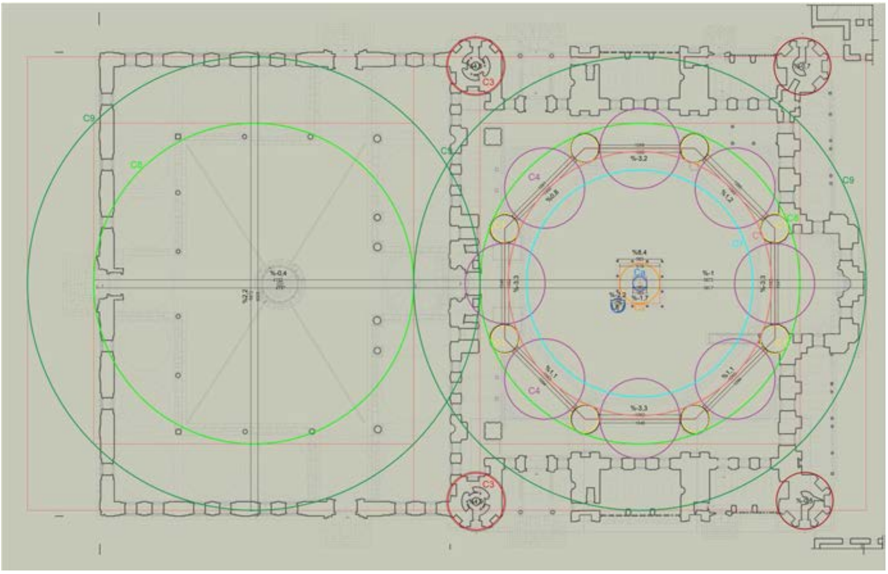

Fig. 14 Selected dimensions and their deviations annotated on the plan

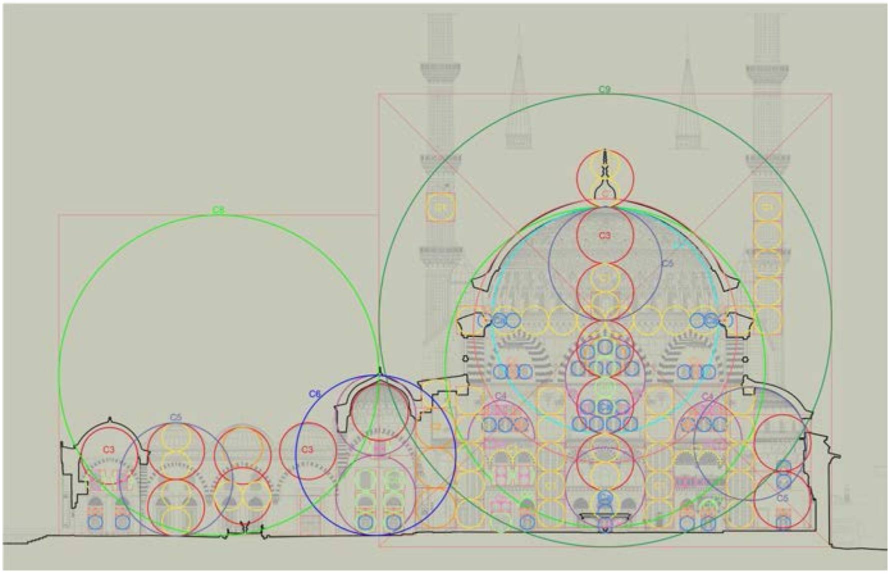

Fig. 15 Analysis of the section of the Selimiye Mosque

modules also fit every space of the structure. However, some modules align with the associated spaces primarily in terms of one-dimensional side lengths rather than full areal overlap. There are also minor displacements when the proposed

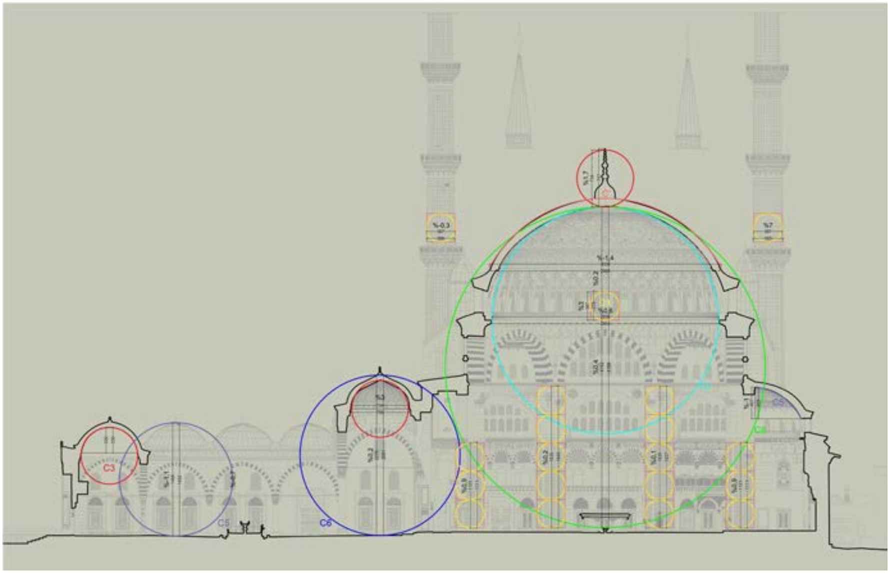

Fig. 16 Selected dimensions and their deviations annotated on the section

modules are compared with the current plan. The consistency between the modules and the plan dimensions has been expressed as percentage deviations.

It may be argued that certain discrepancies between the building's plan scheme and the ideal modulation system likely stem from structural and functional constraints inherent to its program. Alternatively, it may also be considered that Sinan had not yet applied, at this earlier stage, the level of refined care that he would later demonstrate in the two masterworks discussed above. Nevertheless, it is noteworthy that the two pairs of frigidariums and caldariums are externally encircled by a sequence of S4 modules—each with a side length equal to one-quarter of the S8 module—which, when placed adjacently, effectively envelope these four large S8 modules on the exterior. Indeed, the bath complex as a whole appears to be defined by approximately five S4 units along its shorter exterior side and nearly twenty along its longer side, as if corresponding the ratio of 1/5 (Table 3, Figs. 17, 18 and 19).

Conclusion

The absence of original written sources defining the principles of Classical Ottoman architectural modulation has, on one hand, liberated researchers—who rely on the buildings themselves as primary sources—along the path of deductive reasoning; yet on the other hand, it also poses the risk of leading them into subjective interpretations, especially under the allure of geometry and numbers. What has energized this study, however, is not merely the symbolic associations of numbers, but rather the way in which recursively repeated circles appear to function as keys that unlock the modulation systems employed by Architect

Table 3 Moduls with their equivalents and correspondences on the Haseki Hürrem Bath

MODUL	EQUIVALENT	CORRESPONDENCE
CO		• Diameter of the pools in the center of frigidariums • Intersection area of the caldariums
C1	**Modul**	• Wall thickness of the frigidariums • Width of the eyvans' floors
C2	2 x C0	• Floor area of the eyvans
C3	2 x C1	• Depth of the caldariums' eyvans • Floor area of the caldariums' corner cells
C4	2 x C2 *5 ½ arşın*	• Wall thickness of caldariums • Width of the caldariums' corner cells • 1/4th width and 1/1 length of the bath's portico
C5	2 x C3	• Width of the marble platforms in the caldariums
C6	2 x C4	• Inner contours of the frigidariums' galleries
C7	2 x C5	• Outer contour of the frigidariums' galleries
C8	4 x C2, 2 x C6 *22 arşın*	• Outer contours of the frigidariums

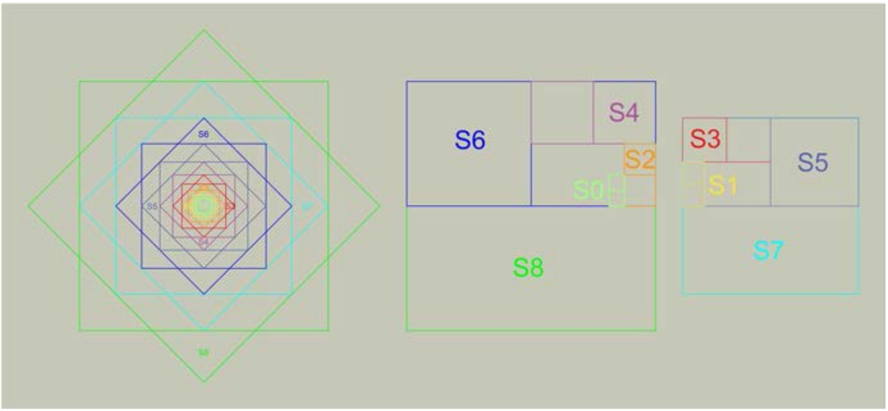

Fig. 17 Scheme of the recursive modular squares

Sinan. This research has thus offered a unique experience in understanding how adherence to the inherent precision and discipline of geometry—often described as the universal alphabet—can guide its practitioner toward an exceptional mastery of design.

The analyses have demonstrated how masterfully Sinan placed the circle at the core of his architectural design. Given the minor deviations annotated on the drawings, each repeated circle and square—far too consistent to be coincidental—was shown to define the most critical components of the buildings. Admittedly, discovering that each module in these selected structures fulfilled a significant spatial role was an extremely exciting experience. The minor deviations observed in certain measurements may plausibly be attributed to inaccuracies in the survey drawings or to measurement errors that occurred during construction.

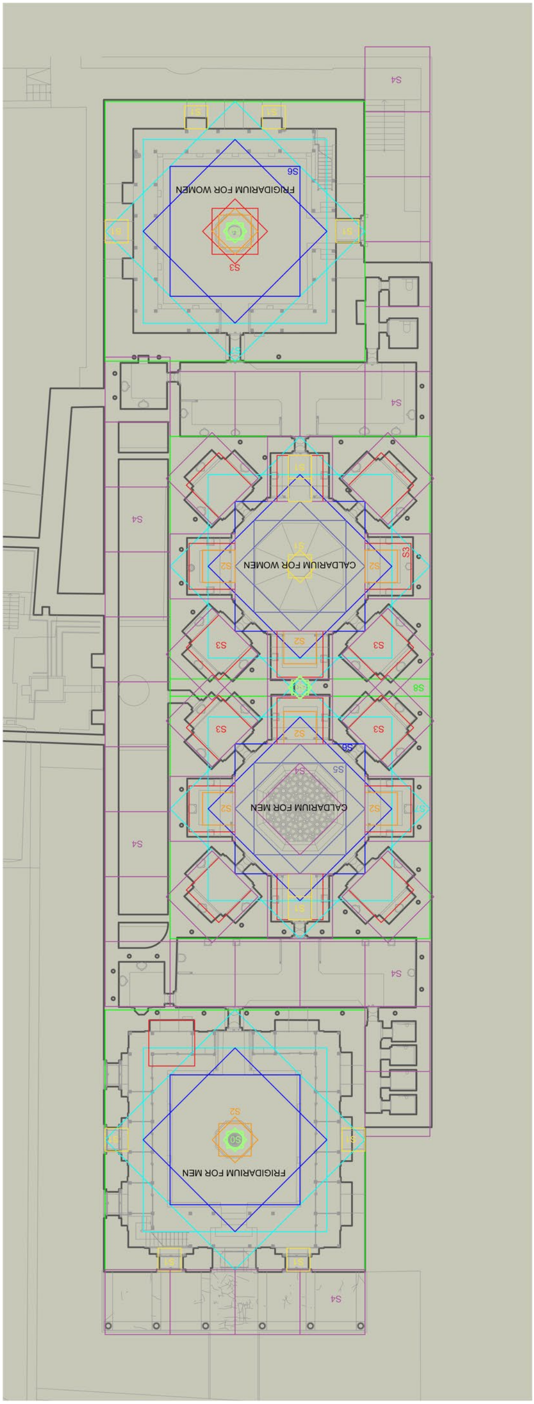

Fig. 18 Analysis of the plan of the Haseki Hürrem Bath

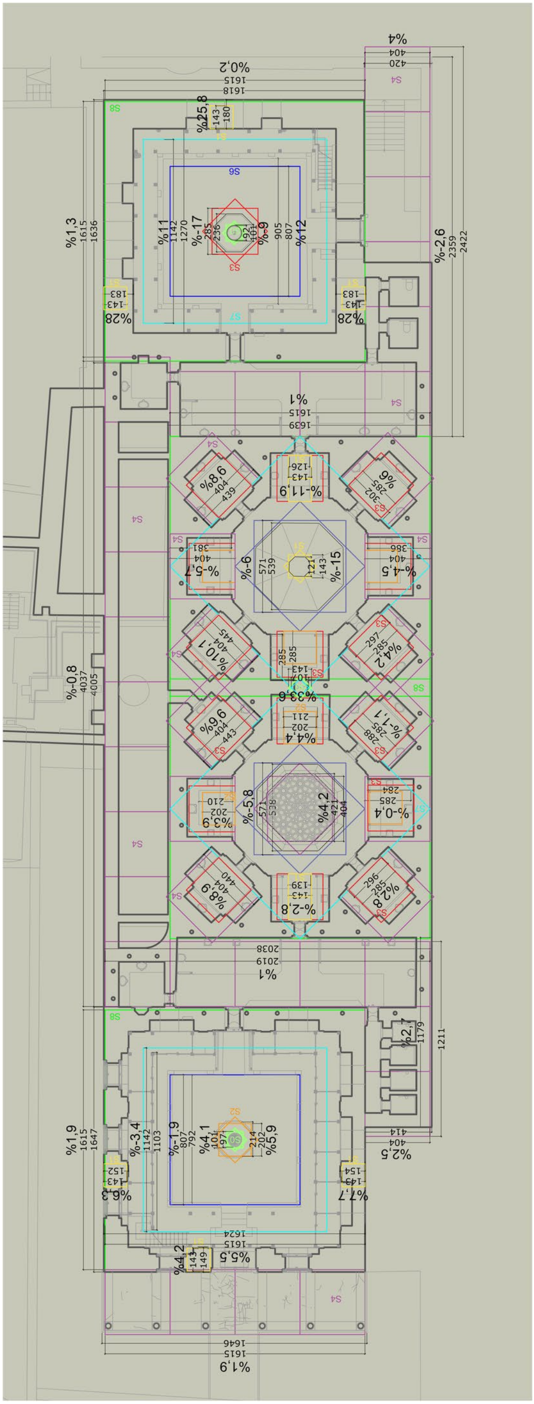

Fig. 19 Selected dimensions and their deviations annotated on the plan

Considering the integer values corresponding to the final levels of iteration, the recursive process of modulation should initially have been derived from the general exterior dimensions of the structure toward the core circle through retrospective recursion. So, the primary modules emerges as the divisions of the proposed dimensions of the structure according to this deductive method.

Exalting an artwork with lavish praise and elevating it to an unattainable and unquestionable realm is a populist and simplistic approach that neither requires the effort of understanding it nor assumes the responsibility of explaining it. Yet even questions that appear complex often have simple answers. One reason genius hides within simplicity is that it remains too obvious to be disclosed. In this article, the geometric analysis of three of Mimar Sinan's masterpieces is presented in a way that could be understood even by a primary school student with basic geometric knowledge.

Ultimately, this research is expected not to remain within the bounds of a limited retrospective inquiry, but rather to inspire new approaches that may offer solutions to contemporary design challenges. In a built environment shaped on one side by self-referential, rootless, and subjective forms produced by egos unconcerned with persuasion or coherence, and on the other by uninspired and lifeless designs created by architects lacking in skill, recalling the compelling and fulfilling ancient language of geometry—at least within architectural education—may offer a sense of hope. In addition, it is also possible that artificial intelligence, when guided by the reassuringly simple language of geometry to generate coherent formal expressions, could present forms that are more persuasive, fulfilling, diverse, and sincere.

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Data availability The relevant official permission slips for the archiectural surveys used in the manuscript are attached as supplemantary material.

Declarations

Conflicts of Interest The author certifies that they have no affiliations with or involvement in any organization or entity with any financial interest or non-financial interest in the subject matter or materials discussed in this manuscript. Architectural data obtained with the permission of the Ministry of Culture and Tourism of the Republic of Türkiye and Architect Tevfik İlter.

References

Arpat, A (1984) Sinan Camilerinde Kutsal (Mistik) Boyutlar ve Modüler Düzen. Türk Dünyası Araşatırmaları 28:1-28

Belardi P (2018) Ölçmek, Çizmek, Bilmek <Misurare Disegnare Conoscere>. Janus, Istanbul

Berkin G, Civelek, Y (2019) Modül ve Mimarlık. Nobel, Istanbul

Bosman AE Het (1957) Wondere Onderzoekıngsveld Der Vlakke Meetkunde. N.V. Vitgeversmaatschappij parcival, Breaa

Burelli AR, Gennaro, P (2008) Die Moschee von Sinan/Sinan's Mosque. Ernst Wasmuth, Tübingen

Cantay T (1986) XVI. Yüzyıl Türk Mimarisinde Bazı Tasarım Ve Çizim Esasları. Paper presented at the 2nd international congress on the history of turkish and islamic science and technology, Istanbul Technical University, Istanbul, 28 April-2 May 1986

Critchlow K (1995) Islamıc Patterns: an Analytical and Cosmological Approach. Thames&Hudson, London

Göller A (2019) Mimarlıkta Üslup Neden Durmadan Değişiyor? <Was ist die Ursache der immerwährenden Stilweränderung in der Architektur?>. Janus, Istanbul

Gregotti V (2017) Mimarlığın Amaçları ve Araçları <Architettura, tecnica, finalità>. Janus, Istanbul

Heilbron JL (2000) Geometry Civilized: History, Culture, Technique. Clarendon, New York

Hiscock N (2000) The Wise Master Builder Platonic Geometry in Plans of Medieval Abbeys and Cathedrals. Routledge, London

Hiscock N (2007) The Symbol at Your Door Number and Geometry in Religious Architecture of the Greek and Latin Middle Ages. Routledge, New York and London

Holme A (2010) Geometry: Our Cultural Heritage. Springer, Berlin Heidelberg

Kuban D (2021) Osmanlı Mimarisi. Yem, Istanbul

Kuran A (1973) Mimar Sinan Yapısı Karapınar II. Selim Camiinin Proporsiyon Sistemi Üzerinde Bir Deneme. Paper presented at the 7th Turkish History Congress, vol II. Türk Tarih Kurumu, Ankara, 25–29 September 1970

Lewcock R (1991) Architects, Craftsmen and Builders: Materials and Techniques. In: Michell G (ed) Architecture of the Islamic World. Thames&Hudson, Hong Kong, pp 112–143

Lund FM (1921) Ad Quadratum A' Study of 'The'geometrıcal Bases' of Classic & Medıeval Relıgıous Archıtecture. Batsford, London

Nasiri S, Sarvdalir AR (2024) Geometrical Origin of Generative Shape Grammars for Islamic Tectonics. Nexus Network Journal 26:177–195. https://doi.org/10.1007/s00004-023-00743-y

Necipoğlu G (2017) Sinan Çağı. Istanbul Bilgi Universitesi, Istanbul

Özdural A (1998) Sinan's Arsin: A Survey of Ottoman Architectural Metrology. In: Necipoğlu G (ed.) Muqarnas XV: An Annual on the Visual Culture of the Islamic World. Brill, Leiden, pp 101–115.

Özdural A (2017) Preliminaries. In: Necipoğlu G (ed.) The Art of Ornamented Geometry: A Persian Compendium on Similar and Complementary Interlocking Figures, Brill, Leiden, Boston, pp 163-173.

Özyalvaç AN (2020a) The Pointed Arch Formations and Comparative Analysis Of Süleymaniye Mosque. JSHSR 7(54): 1518–1530. https://doi.org/10.26450/jshsr.1878

Özyalvaç AN (2020b) Konya Sultan Selim ve İstanbul Yavuz Sultan Selim Camileri'nde Oran Araştırması ve Müellif Mimar Meselesi (12)4: 2117–2141. https://doi.org/10.9737/hist.2020.913

Özyalvaç AN (2025) Numerical Symbolism in Ottoman Architecture: A Unit-Circle-Based Geometric Proportion System in 16th-Century Mosques. Nexus Network Journal (2025). https://doi.org/10.1007/s00004-025-00829-9

Parisi N (2008) Sinan. Progetto e costruzione dello spazio cupolato nell'architettura otomana/Design and construction of the ottoman domed space. Poliba, Italy

Roca A, Juan-Vidal, F, Cipriani L, Fantini F (2024) On Vaulting: Heron's Manuals and Their Role in Roman Dome Design. Nexus Network Journal 26:571–592. https://doi.org/10.1007/s00004-024-00771-2

Rozhkovskaya N (2020) Mathematical Commentary on Le Corbusier's Modulor. Nexus Network Journal 22:411–428. https://doi.org/10.1007/s00004-019-00469-w

Savvides D (2024) Hagia Sophia in Constantinople: Unveiling Its Integrated Conceptual Design Through Comparative Analysis. Nexus Network Journal 26:325–352. https://doi.org/10.1007/s00004-023-00758-5

Schmarsow A, Fiedler K (2019) Mimarlığın Özü ve Mimari Yaratım <Das Wesen der architektonischen Schöpfung / Über Wesen und Geschichte der Baukunst>. Janus, Istanbul
Sertöz AS (2019) Öklid'in Elemanları <Euclid's Elements> Tübitak, Istanbul
Söylemezoğlu HK (1981) Edirne Selimiye Camii (1569–1575). Paper presented at the 1st internatıonal congress of the history of turkish-islamıc science and technology, Istanbul Technical University, Istanbul, 14–18 September 1981
Villard de Honnecourt (1201–1300). Album de dessins et croquis
Wu NY (ed.) (2002) Ad Qıadratum. Routledge, London, New York.

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