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The Corinthian capital of Hermopolis Magna (Egypt) and its geometric analysis

Abstract

Paper presents study on the Hellenistic Corinthian capital (240 BC) from Hermopolis Magna (Egypt). Vitruvian proportions of a capital had been confirmed partly, thus another geometrical solution was analysed. Due to completed geometrical diagrams it became obvious design was rooted in a system created by figures being inscribed into a bigger and a smaller circles equal to a lower and an upper diameters of the column.

Key words: Corinthian capital, Hermopolis Magna, ancient geometry

Introduction

Vitruvius recounts the genesis of the Corinthian capital in romantic fashion in “De Architectura” (Vitruvius 1914, IV, 1, 9, 10, 104–106). The great sculptor Callimachus, he says, noticed a basket set upon a girl’s grave and protected by a roof tile; acanthus leaves had sprung up around it, and their tendrils curled under the tile. Vitruvius commented it with a concise set of proportions that Greek builders were thought to have adopted:

- the abacus slab should be $\frac{1}{7}$ of the capital’s height;
- the capital’s total height equals the column’s lower diameter, while its calathus equals the upper diameter;
- dividing the calathus into three equal zones locates first the lower, then the upper row of acanthus leaves, leaving the third zone for the volutes and the ornament between them;
- the diagonal of the square abacus should equal twice the upper diameter of the column, and thus twice the measure of the calathus;
- each corner recess of the abacus is to be one-eighth of its side.

Since the Renaissance hundreds Corinthian capitals had been analysed following this description. They were carved according to Vitruvian model with modification in a form

of leaves and volutes. Discovery of Hellenistic Corinthian capitals brought a problem, they were not composed according to a perfect description of a Roman author. Still, it is worth stressing that, although Vitruvius wrote at the close of the 1st century BC, we possess no textual description – and thus no sure notion – of the appearance of earlier Corinthian capitals. The discussion that began more than 200 years ago is still ongoing (Heilmeyer 1970; Robertson 1979, 140–162; Pollitt 1986, 247, 248; Lawrence 1996, 138–145; Wilson Jones 1989; 1991; 2015; 2022). It is noteworthy, too, that the proportional canons Vitruvius cites for Ionic columns rely on the treatise of Hermogenes in the 2nd century BC. Yet Hermogenes’ work has not survived, nor have the writings of one Arcesius/Argelius, who is said to have discussed the Ionic and Corinthian orders in the same century. We can only infer that the principles embodied in Hellenistic capitals ca. 360 BC adapted the norms current at the time – perhaps akin to, but possibly quite distinct from, the later Vitruvian model.

There are few scientist who proposed explanation of a problem and presented an origin of the earliest Greek Corinthian capital as a period when form of capital had been individually shaped by Hellenistic artists (Homolle 1916; Ebeling 1924; Pedersen 1989; Scahill 2009). Scholars have tried to account for this divergence by analysing the measurements of individual capitals, hoping thereby to detect further underlying relationships (Bauer 1973). The discrepancy

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itself was long taken as evidence of an early phase, a moment when the rules that Vitruvius would later codify were only beginning to crystallise. Our recent study on Hellenistic capital from Hermopolis Magna in Middle Egypt provide highly suggestive evidence that substantially revises this long-standing perspective.

Corinthian capitals from Hermopolis Magna

Excavations conducted in the 1940s by Alexandria University at Ashmunein (ancient Hermopolis Magna), on the area called the “Agora”, produced a series of striking finds (Wace 1959). Among them there were remnants of sixteen fluted columns with bases and Corinthian capitals of the Hellenistic period (Wace 1946, 13, 14; Wace, Megaw and Skeat 1959, 4–11, pl. 1, pl. 15.2, pl. 16). The group has been dated to about 240 BC, when Greek katoikoi were settled at Hermopolis Magna in Middle Egypt. They evidently set out to raise a range of civic and sacred buildings whose forms would faithfully reflect the style of Greek architecture (Wace 1959, 4–11; von Hesberg 1978; Pensabene 1993, 3–18; Barański 1996; 2004; 2019, 8–10; McKenzie 2007; Hoepfner 2020). The architect at Hermopolis was probably trained in Alexandria, as suggested by the very high quality of the capitals’ carving. In general, these capitals correspond to the Style Group I of Konstantin Ronczewski’s typology of Corinthian capitals (Ronczewski 1927), the group that includes some similar examples to earliest capitals from the Epidauros Tholos, built in 360 BC.

The discovered Hermopolis capitals display crushed corner volutes; more importantly, traces of their original polychromy were discovered on the surfaces, greatly enhancing the significance of the find. One of the capitals was taken to the Graeco-Roman Museum in Alexandria, where it became a prized exhibit – though not prized enough to prompt thorough documentation or analysis. It has been reproduced time and again in surveys of Hellenistic art and architecture, yet always without in-depth study (Adriani 1972, 124, 125, tav. XV; Pensabene 1993, 324, tav. 8, 43–47; Bauer 1973, 117, 122, 123, taf. 32.5; von Hesberg 1978, 138, fig. 131; McKenzie 2007, 56; Bassioni 2022, 46).

In 1987, while working in the Hermopolis – Ashmunein Basilica as part of the Polish–Egyptian Mission, I undertook a systematic study of this Hellenistic capital (Barański 1996, 104; 2004; 2019, 9, 10, figs. 1–4). The discovery of its missing corner volute during excavation made an almost complete reconstruction possible. I executed a documentary drawing at a scale of 1 : 5 that records the capital’s form in full (Fig. 1a, b). It should be noted that in 2020 Wolfram Hoepfner, in his study of the Hellenistic finds from Hermopolis, presented his own colour drawing of the capital, derived from Wace’s description (Hoepfner 2020, 43–45, abb. 33, 35, 36, 49, 51). Nevertheless, in that reconstruction the corner volutes are rendered too large, altering the overall proportions of the piece, while a closer inspection reveals several additional inaccuracies, suggesting that the drawing was executed from photographs rather than from direct measurement.



Fig. 1. Corinthian capital from Hermopolis Magna:

a) capital with discovered corner volute (photo by M. Barański), b) coloured reconstruction of a capital (drawing by M. Barański)

Il. 1. Koryncki kapitel z Hermopolis Magna:

a) kapitel ze znaną wolutą (fot. M. Barański), b) kolorowana rekonstrukcja kapitelu (rys. M. Barański)

Revising the capital's proportions

In the next phase of inquiry I analysed the proportions of the reconstructed capital and found that only certain elements conform to Vitruvius' canon. Before moving on to a proportional analysis, it was necessary to set out the capital's overall dimensions. I found a problem when compare dimension taken at the site with those published by Patricio Pensabene, who recorded the museal capital – a total height of 89 cm; a lower-leaf zone of 25.3 cm; an upper-leaf zone of 39 cm; a calathus height of 78 cm; and an abacus height of 11.4 cm (Pensabene 1993, 324). Pensabene also mentioned a scamillus diameter of 80 cm, but he did not supply the lower column diameter, because only the capital – without its base – had been transported to the museum. A simple division of the capital's height by that of the abacus yields the unusual ratio of 1 : 6.80, which might be accepted as plausible. Yet if one divides the overall height into seven equal parts and the calathus into six, the resulting abacus units differ (12.71 cm vs. 13 cm). Nor is the arithmetical sum of Pensabene's figures satisfactory: 78 cm + 11.4 cm produces 89.4 cm, and not the stated 89 cm.

Subsequent measurements taken on site at Ashmunein differ slightly. The calathus height is 77.4 cm and the abacus proper 11.4 cm, giving a combined height of 88.8 cm. Above the abacus a further 1.4 cm of stone was left as a working margin, a ledge. In my first analytical step, following Pensabene, I adopted a capital height of 88.8–89 cm, an abacus height of 11.4 cm, and a corrected calathus height of 77.4 cm; but the resulting abacus-to-capital ratio of roughly 1 : 6.8–7 remained unsatisfactory (Barański 2019, 9). The capital's height was therefore adjusted to its true dimension of approximately 90–90.2 cm, a figure that includes the 1.4 cm of surplus stone intentionally left on the abacus. With this margin, a ledge – destined to bear the architrave – the capital fulfilled a cardinal proportional rule of the architectural order. The slight recess cut at the abacus corners, forming this way a ledge was probably dictated by the relative softness of the limestone: if the corners had been fully finished, there was a real risk that they could be damaged during mounting an architrave. Significantly, the corrected height also matches the measured lower diameter of the column, which is likewise about 90 cm. Once this dimension is incorporated into the abacus measurement, the numerical discrepancies disappear and all figures agree.

At this height the capital can be divided into seven equal parts, yielding an abacus unit of 12.8–12.9 cm. That same unit suits the calathus when it is divided into six parts, for its measured height of 77.4 cm likewise equals six units of 12.88–12.9 cm. The working assumption, then, is that the capital was laid out according to a single abacus module common to both the capital as a whole and the calathus; the unit should be identical in each case. Such a scheme would corroborate Vitruvius' partitioning. In consequence, one-seventh of the abacus slab and the overall heights of both the capital and the calathus correspond to the lower and upper diameters of the column. This yields a set of regular divisions in which normal workmanship tolerances of roughly 3–5 mm may be allowed. Ultimately, the abacus

module may be reckoned either as 1/7 of the capital's height or as 1/6 of the calathus height.

In accordance with Vitruvius' prescription, the width of the abacus slab can be determined by treating its diagonal as the equivalent of two upper diameters of the column shaft – that is, twice the height of the calathus (Fig. 2a). On this basis the abacus diagonal should measure $2 \times 77.4 \text{ cm} = 154.8 \text{ cm}$. Dividing this value by $\sqrt{2}$ to obtain the side of the square yields 109.45 cm, or approximately 109.5 cm. As a control, the calculation may be repeated using the lower diameter – namely, the capital's total height – which gives a diagonal of $2 \times 90.2 \text{ cm} = 180.4 \text{ cm}$ and a resulting side of circa 127.7 cm. Although this second figure appears to approach ten abacus modules of 12.9 cm each, the discrepancy is in fact too great to justify such a reading. When the two alternative abacus sizes are plotted on the reconstruction drawing, the corners derived from the upper-diameter scheme sit neatly, whereas those derived from the lower-diameter scheme project well beyond the volutes. In the discussion that follows this mismatch will not affect our analysis of the decorative proportions, but we shall return to the question of how the abacus dimension was established.

According to Vitruvius' description, the calathus should be divided arithmetically into three equal parts in order to fix the positions of the leaves and the volutes. In the Hermopolis capital, however, the subdivision is different. The height of the upper leaves equals exactly one-half of the calathus height, while one-half of the entire capital height marks a distinctive level situated above the upper leaves; this line passes through the stalks of the inner flowers and through the collars of the middle stems.

A further test experiment was therefore made with a smaller unit, dividing not into three but into six parts, yet this scheme added little. A division into eight parts was also tested – prompted by the number of corner volutes and of leaf tiers – but that analysis likewise failed to yield a satisfactory solution. It was observed, meanwhile, that a number of characteristic points on the capital are determined by modular grids; still, identifying several key points did not by itself explain the overall composition. One additional result of these trials was the realisation that the divisions employed in the capital could expand from a smaller to a larger “circle”.

Even more surprising was the discovery that the relations derived from the column diameters can be linked to the base in the following way. The base height equals two modular units (marked at drawings as a UV), so that when the base and capital are combined the total comes to nine units of the abacus measure. Remarkably, those nine units correspond to the lower torus diameter of the base, while the upper torus diameter equals eight such units. Thus four concentric circles are introduced: “A” comprising seven units, “B” six units, “C” eight units, and “D” nine units, all referred to the abacus module [These circles would measure, respectively, $A = 90.2 \text{ cm}$, $B = 77.4 \text{ cm}$, $C = 103.2 \text{ cm}$, and $D = 116.1 \text{ cm}$] (Fig. 2b). Although such a direct linkage of capital and base is never encountered in practice, it signals that additional dependencies may exist, influencing the mutual relationships of the order's components – dependencies that ought perhaps to be taken into account in the analysis. These

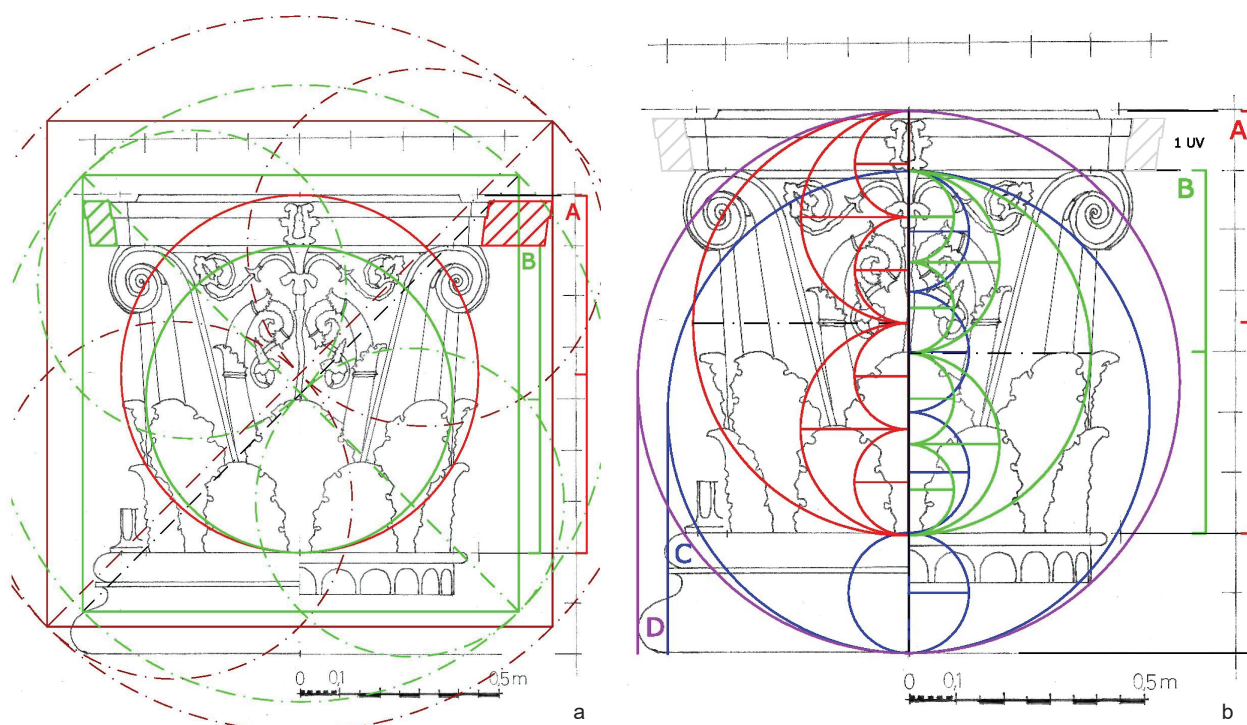


Fig. 2. Hermopolis capital: a) geometric reconstruction of an abacus size depending a lower (red) and upper (green) diameter of a column trunk. Upper diameter (green) indicates a right solution, b) partition of capital and base following section of circles A, B, C, D by 4 and 8. Vitruvian partition unite (UV) of a measuring 1/7 of overall capital height and equal to abacus size (elaborated by M. Barański, drawing by K. Jezierski)

Il. 2. Kapitel z Hermopolis: a) geometryczna rekonstrukcja wielkości abakusa w zależności od dolnej (czerwona) i górnej (zielona) średnicy trzonu kolumny. Górna (zielona) średnica wskazuje właściwe rozwiązanie, b) podział kapitelu i bazy według kół A, B, C, D mających podział na 4 i 8. Witruiwska jednostka podziału (UV) mająca wielkość 1/7 wysokości całego kapitelu odpowiada wielkości abakusa (oprac. M. Barański, rys. K. Jezierski)

interconnections pertain not only to simple vertical subdivision but also to the horizontal layout, where the base dimensions represent a modular enlargement of the lower column diameter. Here, we should mention, a horizontal division of circles by 4, 8, 12 provides a general distribution of capital volutes, and leaves of upper and lower row. While these observations were helpful, they did not yet provide a clear key to the arrangement of the capital's decorative scheme.

Another concept of a modular grid adoption was also analysed. The Egyptians employed precisely such a system in their reliefs and architecture, enabling them to coordinate dimensions and to position distinctive points within a sculptural composition (Rossi 2007, 113–127). It is quite possible that a comparable modular grid – conceived as a matrix or template – was likewise used when carving the capital itself. Such a device would have allowed the sculptor, as the work progressed, to verify the placement of critical points on every face of the block, in both the vertical and horizontal axes. Although no finished examples of stones so prepared have survived, incised guidelines on Roman blocks have been documented and analysed (Asgari 1988; Toma 2015). A comparable system of setting-out lines is attested on late-Hellenistic monuments in Nabataean kingdom, whose builders were influenced by Ptolemaic architects (Dentzer-Feydy 1995). Scribed lines preserved on the upper and lower faces of capital show that these marks served not only to position leaves axes, but also control carving depth; yet characteristic points on the side faces must also have

been defined. Asgari demonstrated how a threefold subdivision of the capital was used, step by step, to obtain its final form. In a Roman capital, the volutes could be produced simply by trimming the corners to the required profile; in a Hellenistic capital the same method was followed, but with greater care to establish the exact positions of the key features. Marking the half-height of either the capital or the *calathus* could have been achieved arithmetically, while the abacus furnished the principal vertical datum. The acanthus leaves of both Hellenistic and Roman capitals were laid out and carved in essentially the same way. Above the leaves, however, the Hellenistic capital demanded far greater precision: unlike its Roman counterpart, its upper, exposed zone gives full prominence to vegetal detail, leaving no scope for error or for the carver's whim. Any executional deviations therefore had to be tiny. An appropriately prepared template, used throughout the carving process, would have allowed continuous three-dimensional checks.

If the capital's design was an individual project, it must nonetheless have obeyed certain rules – and those rules probably did not rest on a mere arithmetic partition. Could a geometric model have been employed? One therefore asks whether the circular diameters that correspond to the heights of the capital and the *calathus* might be linked to still other subdivisions. A further issue is the possible influence of Egyptian mathematical knowledge on the solutions adopted by Ptolemaic scholars and architects (Rossi 2007). The literature on the geometric conception of pyra-

mids and temple plans is extensive; such expertise differed from Greek practice, and we know that in Egypt Hellenistic builders did not confine themselves to purely Greek-style temples. The traffic in mathematical ideas and architectural concepts may thus have been two-way.

For more than a century scholars have examined ancient, a well Gothic monuments and works of art in search of the practical use of geometry – projecting designs and shaping representations by means of geometric constructions, figures, and their transformations. There are studies by Matila Ghyka and Otto Hagenmaier as well Jay Hambidge, Macody Lund, Ernst Mössel set a special interest on application of geometry and the “golden section”. Why not to examine a Capital from Hermopolis as a geometrical design?

The capital's geometry

Attempting to test geometry of a capital, I had not considered Vitruvius description on a method establishing a size of an abacus plinth as a real geometrical principle. In fact his saying about a diagonal of an abacus square was a pure geometry establishing its incommensurable length. It was in contrary to an overall arithmetical system used for partition of a capital. At that stage of the study, Vitruvius description had been considered as a simple and practical method, without a deeper geometrical idea.

Geometry makes its appearance in the capital the moment a square is described upon a circle; conversely, a cylinder can be inscribed in – and extracted from – the cube whose side equals that square, as has been recognised for Roman capitals. The system of successive squares, and of the circles inscribed within them, could in principle be extended *ad infinitum* by applying the “duplication of the square” construction discussed in Plato's *Meno*: the diagonal of a square whose side is a (or $2a$) is incommensurable, measuring $a\sqrt{2}$ (or $2a\sqrt{2}$). From the side of the initial square, therefore, one can generate a larger square and inscribe within it a larger circle (Saito 1995; Rossi 2006, 88–90; Scott 2006). Other polygons can likewise be set within the circle, binding them geometrically to the square (Fowler 1999, 32–34).

In analysing the present capital, however, both circles corresponding to the lower and the upper column diameters – the capital height and the calathus height – had to be taken into account, since their centres are displaced from one another by one-half of the abacus module. The question then arose: would that offset generate further relationships that locate any characteristic points on the capital? It is not impossible that the capital's dimensions were also partitioned by means of the golden section, which Plato refers to as the “mean ratio” (Ghyka 2001, 41–75; Naredi-Rainer 1982, 193–199; Hagenmaier 1977; Beutelspracher, Petri 1996; Fowler 1999, 84, 85; Rossi 2007, 23–32, 67). This opens up a considerable range of geometric possibilities – all of which must be tested against the fabric of the capital itself.

The performed diagrams are accompanied by the following, two-level system of notation:

– General geometric rules are expressed with lower-case symbols – for example a , b , $2a$, $1/2a$, $a\sqrt{3}$ – which refer simply to lengths or operations in the abstract.

– Constructions specific to the capital are denoted by capital letters and by colour:

◦ **A** (red) designates every figure – side A, circle A, red triangle, red square, red hexagon – drawn on the lower diameter of the column shaft, that is, on the capital's overall height. Diameter A consists of 2 radiuses $\underline{a}$, thus $\underline{a}$ is equal to $1/2A$.

◦ **B** (green) refers to the corresponding figures – circle B, side B, and so forth – constructed on the upper diameter of the shaft, which equals the calathus height. Diameter B consists of 2 radiuses $\underline{b}$.

◦ A second, equally important point: some geometric operations are checked arithmetically, and the numerical results are recorded in square brackets. This dual procedure makes it possible to test whether the constructed diagrams are genuinely compatible with the mathematical calculations based on the two fundamental dimensions – the lower and upper shaft diameters, corresponding respectively to the heights of the capital and the calathus. In many instances the arithmetic values will not coincide perfectly with the drawn figures, because each construction belongs strictly to magnitude A or magnitude B; the figures may therefore differ by a minute margin. What is striking, however, is the remarkable closeness of the solutions that emerge.

When the geometric analysis began – an exploratory exercise at first – the two circles, red and green, were traced on the capital's ground plan and squares were described upon them. Their diagonals were then drawn, producing right-angled triangles. That single subdivision already pointed to a number of intriguing loci in the layout of the decoration of the capital.

The next step was to construct two equilateral triangles, with sides A and B, respectively, their bases laid along the bottom edge of the capital (Fig. 3). Choosing the equilateral triangle at the outset was a matter of chance; it is not that the author was prompted by Plato's dictum on the use of that figure in generating the regular polyhedra that constitute the fabric of the cosmos (Plato 2016, *Timaeus* 53c). At this preliminary stage, moreover, I was unaware of Euclid's construction of an equilateral triangle inscribed in a circle. The diagram was devised on the basis of nothing more than elementary school geometry.

The very first equilateral triangle, its side B placed on the capital's base, produced an apex that fell precisely on the centre of the stalk of the central flower. This was an interesting result – though one that might still have been no more than fortuitous. The height marked by the first equilateral triangle proved noteworthy, for it coincides almost exactly with the level of the centres of the corner volutes. A second, analogous equilateral triangle with side A was then drawn; its apex, only slightly higher, fell almost precisely on the underside of the abacus – an outcome no less striking. [The height obtained for equilateral triangle B is 67.03 cm. The height of equilateral triangle A is 78.1 cm, whereas the diameter of circle B equals 77.4 cm, a difference of merely 6–7 mm over the capital's full height of 90.2 cm, with an average error of 0.66–0.77%].

The same procedure was applied to side C, corresponding to the upper torus diameter of the base, and to side D,

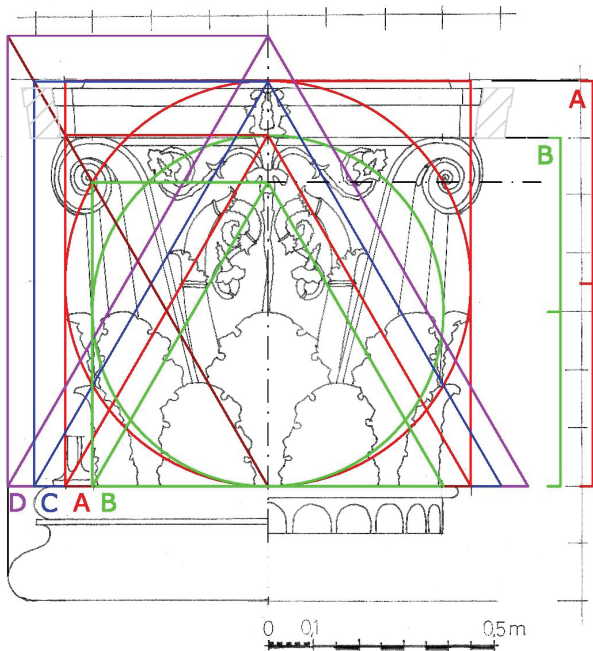


Fig. 3. Construction of equilateral triangles of a side equal to A, B, C, D diameters. Apexes of A and B triangles designates a characteristic points and lines of the capital (elaborated by M. Barański, drawing by K. Jezierski)

Il. 3. Konstrukcja trójkątów równoramiennych o bokach równych średnicom kół A, B, C, D. Wierzchołki trójkątów A i B wyznaczają charakterystyczne punkty i linie kapiteła (oprac. M. Barański, rys. K. Jezierski)

the lower torus diameter – eight and nine abacus units of 12.9 cm, respectively. The apex of triangle D clearly rose above the capital, while that of triangle C lay very close to the capital's overall height. In the analyses that followed the diameters associated with circles C and D were therefore set aside, and attention focused on the figures constructed for A and B.

For certainty, the apex levels of triangles A, B, and C were recalculated arithmetically. Although they lie near one another, differences greater than a centimetre make it difficult to accept them as points that coincide exactly with the capital's characteristic levels [apex of triangle C = 89.37 cm, when height of the capital is 90–90.2 cm; apex of triangle D = 103.1–103.2 cm]. Even so, the close agreement between the apices of triangles B and C and the heights of the top of the calathus (77.4 cm) and of the whole capital (90.2 cm) may well have offered the ancient designers a clue or guideline, despite the small error – about one per cent by modern reckoning. We must bear in mind that ancient mathematics could not compute irrational numbers with modern exactitude. Magnitudes were determined geometrically and rounded with great, though not absolute, precision; millimetre-scale discrepancies would have been considered negligible. It is therefore plausible that, in Vitruvius' simplified description, such slight deviations were deemed unimportant, allowing the outcome of this geometric construction to be expressed as the simple, generalised partition of $1/7$.

In my next operation, the equilateral triangles were drawn in the reverse orientation, their apex now placed at the centre of the capital's base (Fig. 4). This time the api-

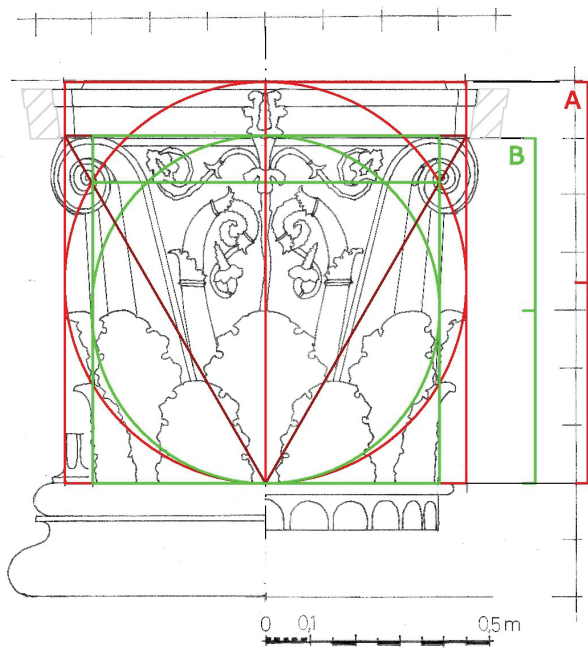


Fig. 4. Inversion of equilateral triangles A and B marks centers of a corner volutes (elaborated by M. Barański, drawing by K. Jezierski)

Il. 4. Odwrocenie trójkątów równobocznych A i B wyznacza centra narożnych wolut (oprac. M. Barański, rys. K. Jezierski)

ces of equilateral triangle B marked not only the level of the centres of the corner volutes [67.03 cm] but also, with almost perfect accuracy, the reconstructed centres of the volutes themselves; the small error visible in the drawing is probably the result of an inevitable imprecision in the reconstruction. A further coincidence proved equally intriguing: the side of triangle B intersected the smaller circle at a pair of highly characteristic points – namely, those at which the tangent line fixes the inclination of the stems before it turns into the corner volutes. We shall return to this matter later.

Surprised by these observations, I next drew a large equilateral triangle with side A equal to the lower diameter of the column shaft (Fig. 5). As might be expected, one side of this triangle indicated almost exactly the lower face of the abacus slab, a level that had already been fixed by the larger circle. What is more, it became evident that the larger circle A, with its greater diameter, met – approximately – the corners of the smaller triangle B, which had already, again approximately, located the volute centres. This geometrical diagram was at once unexpected and stimulating, and it encouraged a search for additional constructions. At this stage of the analysis some diagrams were produced almost accidentally, yet the drawings themselves began to suggest the next steps to be taken.

In the next stage of the investigation the construction of right-angled triangles was tested (Fig. 6). As is well known, two types of right triangle can be inscribed in a circle of radius a being equal to $1/2A$. The first is isosceles, with catheti measuring $1/2a\sqrt{2}$ and a hypotenuse equal to the diameter $2a$; its apex coincides with the centre of the circle and of the square that can be inscribed in it. The second has

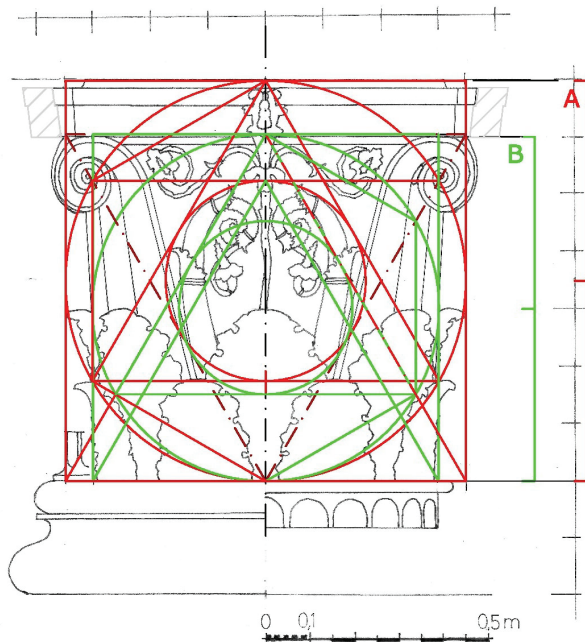


Fig. 5. Equilateral triangles inscribed into A and B circle. Pairs of triangles A and B generate a hexagone A and B respectively. Apexes of a hexagon A marks characteristic points of a capital. Triangles also designate a smaller inscribed circles of $1/2A$ and $1/2B$ diameter, when a circle of $1/2A$ frames a central decoration of the capital (elaborated by M. Barański, drawing by K. Jezierski)

Il. 5. Równoboczne trójkąty wpisane w koła A i B. Pary trójkątów A i B tworzą odpowiednio sześciokąty A i B. Wierzchołki sześciokątów wyznaczają charakterystyczne punkty kapitelu. Trójkąty wyznaczają również mniejsze wpisane koła o średnicach $1/2A$ i $1/2B$, gdzie koło $1/2A$ obejmuje centralną dekorację kapitelu (oprac. M. Barański, rys. K. Jezierski)

catheti a and $1/2a\sqrt{3}$, with the same hypotenuse $2a$. Both varieties were drawn in circles A and B.

The apex of the larger, red triangle A fell almost exactly on the centres of the volutes – points already indicated by the height of the smaller, green equilateral triangle B. When the shorter cathetus of this right triangle was set off along its hypotenuse, which serves as the axis of our geometric scheme, the distance obtained corresponded to the diameter of the smaller green circle B. Thus yet another composite relationship emerged, derived from the two diameters A and B.

At this moment memory supplied a schoolroom fact: using right triangles – rather than merely stepping the compass round the circumference – one can likewise construct a hexagon inside a circle. Hexagons were therefore drawn in both circle A and circle B. The outcome was no less striking than before. The apex of the right triangle whose hypotenuse equals diameter A and whose shorter cathetus equals the radius a ($1/2A$) landed virtually in the centre of a volute. As noted earlier, the volute-centres lie on the level determined by the equilateral triangle of side B (67.03 cm); consequently the longer cathetus of this right triangle exactly equals side B. If the same right triangle is inverted, its apex marks a distinctive point that is the lower vertex of the hexagon inscribed in the red circle A. These lower vertices establish the level of the capital's lower acanthus leaves.

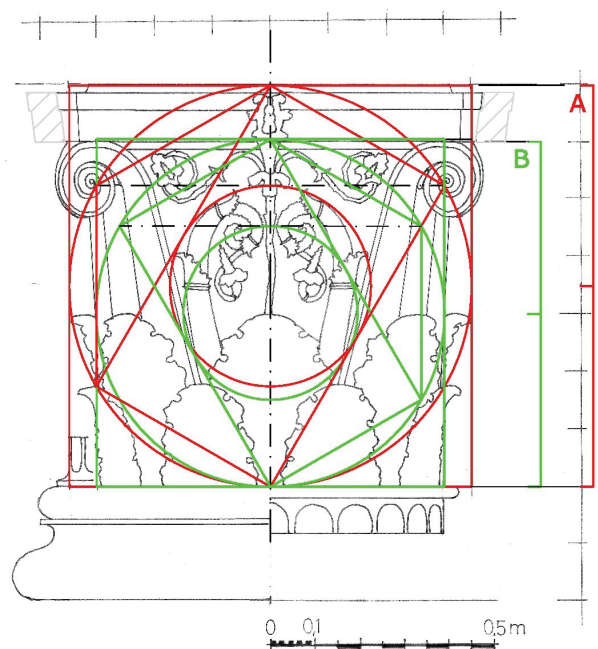


Fig. 6. Points designating by hexagon are mutual to points designated by a right triangles of hypotenuse equal to a diameter of A and B circles. Pairs of triangles construct rectangles A and B respectively (elaborated by M. Barański, drawing by K. Jezierski)

Il. 6. Punkty wyznaczone przez sześciokąt są również punktami wyznaczającymi trójkąty prostokątne o przeciwprostokątnej równej średnicom kół A i B. Pary trójkątów konstruują odpowiednio prostokąty A i B (oprac. M. Barański, rys. K. Jezierski)

When the analogous right triangle B was constructed for the smaller green circle, the results were less spectacular but still significant. The upper vertices of the smaller hexagon B coincide, with high probability, with the terminations of the middle blossoms and thereby with the junction of the intermediate volutes; its lower vertices fix the plane where the lower leaves begin to bend outward.

The composite figure derived from superimposing the two right triangles A and B not only provided the six vertices of the hexagon: it produced a six-pointed star – the familiar form generated by two equilateral triangles rotated relative to one another and inscribed in the same circle. Inscribing figures in a circle is, of course, no more than a consequence of geometric law; yet this diagram yielded another, wholly unexpected curiosity. The side of the equilateral triangle inscribed in circle A is exactly equal to the diameter of circle B. No such coincidence had been anticipated, and it emphatically confirms the internal relationships between the two circles.

It was further observed that in this diagram an additional conjunction of figures occurs: the red hexagon A almost rests against the side of the green square B. This may be no more than a chance juxtaposition, yet it could equally be a consequence of the 7 : 6 ratio adopted for the two circles. An arithmetical check of the relevant dimensions reveals only minute discrepancies – something we must bear in mind when analysing the geometry of such a scheme. [The side of hexagon A is one-half of the 90.2 cm diameter, that is, 45.1 cm. From this one can calculate the hexagon's "height" (the distance between two opposite sides), which

is 78.1 cm. This is greater than the side of square B, which measures 77.4 cm, the difference being ca. 7 mm, thus an average error is 1%. We should remember, however, that the divergence between the side of a square and the side of a hexagon constructed on the same centre amounts to only half that value – i.e. 3.5 mm, thus an average error is significantly diminished].

The basic diagram was then expanded with a further set of constructions. Attention was drawn to the paths taken by the catheti of the two right-angled triangles. It turns out that each cathetus is tangent to a subsidiary circle whose diameter is $1/2A$, and likewise to a second, still smaller circle whose diameter is $1/2B$. The centres of these two subsidiary circles are displaced from one another by exactly half an abacus unit of one-seventh of the capital's height. The diameters of the smaller circles coincide with the sides of the hexagons inscribed in circles A and B. Even more telling is the fact that the $1/2A$ circle fits neatly into a rectangle whose shorter side measures $1/2A$ and whose longer side equals B; this longer side is the very cathetus that previously fixed the volute centres and the level of the lower leaves. The arrangement follows inevitably from the geometry of the construction. A comparable configuration can be drawn for the smaller $1/2B$ circle, although its enclosing rectangle lacks such striking side-lengths. Remarkably, however, the circle of diameter $1/2A$ defines the span of the capital's central decoration, and the $1/2B$ circle performs a similar function – though within a slightly different zone.

Inscribing those right-angled triangles in the two circles opened the way to further geometric operations. Two such triangles can be combined to generate a rectangle whose diagonal equals the diameter A being equal to 2 radiuses a , whose shorter side measures a , and whose longer side measures $1/2a\sqrt{3}$. If two of these rectangles are set perpendicular to one another, their overlap forms a square with side a ; within that square one may inscribe a circle of diameter a equal to $1/2A$. On the common axis of the larger circle (of 2 radiuses a , being equal to A diameter) one can likewise erect two right-angled triangles whose vertices, when joined, produce a hexagon with side a . That hexagon, however, can also be obtained in a different way: first inscribe an equilateral triangle in the circle, then add a second, inverted triangle of the same size. The resulting six-pointed star is composed of twelve small equilateral triangles, each having a side equal to one-third of the side of the original triangle. The intersections of the star's arms mark out a smaller hexagon, within which yet another circle of diameter a can be drawn.

All figures inscribed in the circle of diameter $2a$ or A, thus share a common inner circle of diameter being equal to radius a . What interests us here is that this apparently "simple" geometry, carried out only with compass and straight-edge, no longer yields simple arithmetic: the side of the isosceles triangle inscribed in the circle is irrational ($a\sqrt{3}$), just as the hexagon described on the same circle with a side of an identical length $A\sqrt{3}$. In the course of the analysis we meet a constant passage from larger to smaller figures and from rational to irrational magnitudes, only to return again to rational ones – a chain of interlocking geometric relationships. Although these observations produced

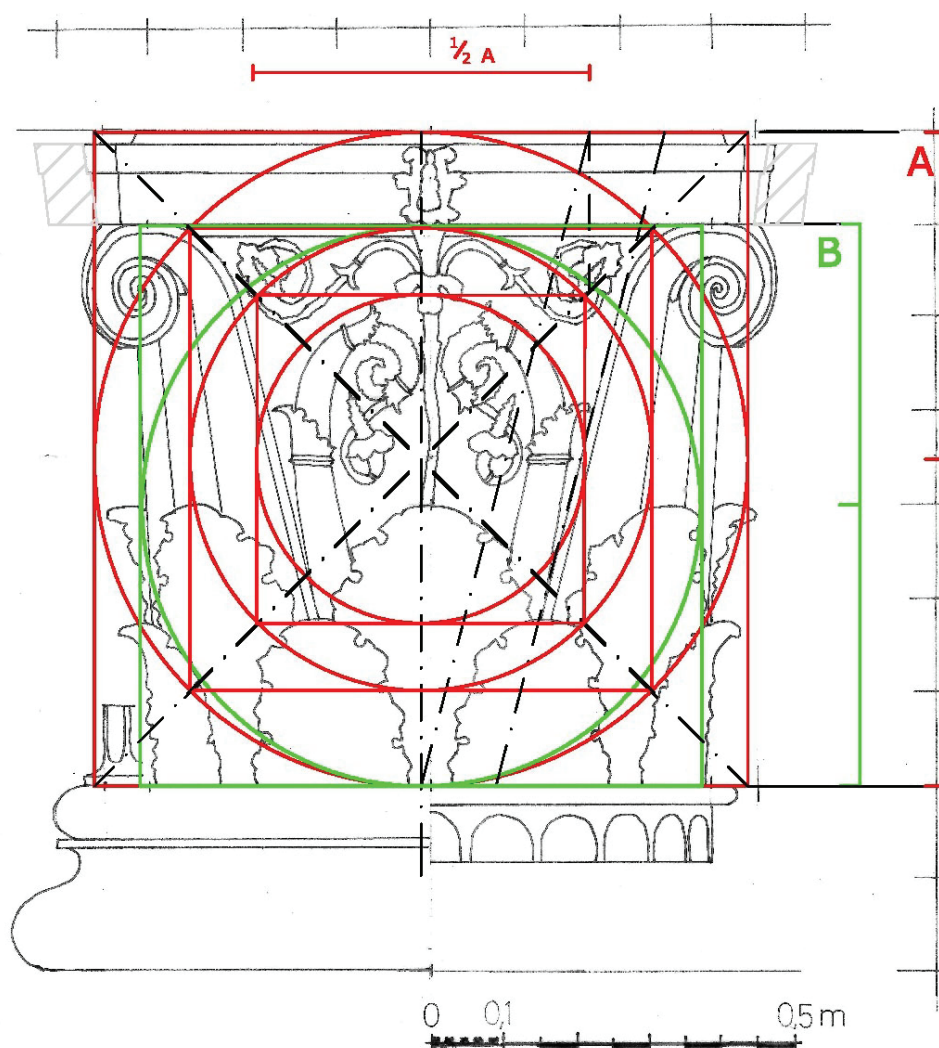
suggestive results and stimulating ideas, they did not yet explain the capital's overall composition.

Defining the subsidiary circles with diameters $1/2A$ and $1/2B$ – which embrace the central zone of the capital's decoration – drew attention to another possibility: constructing a geometric progression based on the sequence $a : a\sqrt{2} : 2a : 2a\sqrt{2}$. The scheme relies on inscribing a square in a circle and then inscribing a second circle about that square. Such a relation was often exploited in the Middle Ages "dubbed *ad quadratum*" (Naredi-Rainer 1982, 218, 219; Rossi 2007, 65, 66; Majewski 2013, 141, 142) and it reproduces the "duplication of the square" that Plato sets out in the *Meno* – NB this procedure is not connected to the famous procedure of "squaring the circle", which asks whether one can construct, with only a straightedge and compass, a square having the same area as a given circle (Hobson 1913, 14–22; Rossi 2007, 67, 68). When this inverted diagram was applied to the capital, the result was dizzying: almost every corner of the progressively smaller squares seemed to coincide with a significant detail. Two steps, however, appeared genuinely meaningful (Fig. 7). Beginning with circle A, the first operation yields square A_1 , inscribed in that circle. The level of A_1 's upper side corresponds, in broad terms, to the lower edge of the abacus, though it is not identical with it; that lower edge, as we know, is defined by the side of square B described on the *calathus* circle B. The lower vertices of A_1 rest on the tips of the capital's lowest leaves. A second iteration produces circle and square A_2 , each with a diameter and side of $1/2A$. Here the upper corners of square A_2 support the lateral blossoms, and, as previous constructions have shown, circle A_2 is identical with the subsidiary circle obtained from the right-angled triangles and from the equilateral triangle inscribed in the $2A$ circle. Circle A_2 neatly encloses every element of the capital's central ornament. Repeating the same procedure for circle B reveals that the vertices of square B_1 touch the inner edges of the stems from which the corner volutes emerge. The circle inscribed in B_1 likewise frames part of the capital's central decoration. A still smaller square, B_2 (side $1/2B$), has an upper side that marks the junction of the intermediate volutes, while its vertical sides intersect the stems at mid-height. Whether these intersections truly determine the inclination of the stems remains open to question; merely picking out conspicuous subdivisions and points on the capital proved unsatisfying and did not yield a fully coherent constructive schema.

To resolve this problem the following solution was provided (Fig. 8). Tangents were drawn along the outer edges of the stems, and it became clear that – below, outside the capital – these tangents meet at a single point. At the top they also intersect the extensions of the sides of squares A and B. Working first with the B-dimension, I connected that lower intersection-point with the two points where the tangents meet the prolongations of the sides of square B. The three points form an isosceles triangle of striking height: it equals two diameters of the smaller circle B, the two diameters touching one another at the centre of the *calathus* – in other words, the *calathus* height has been enlarged on each side by the radius $1/2B$. Discovering that the inclination of the stems could be fixed by a purely geometric construction

Fig. 7. Geometrical sequence of a circle inscribed into a square of A side. In a second step a central circle measuring $1/2A$ is reached, and this is equal to radius a (elaborated by M. Barański, drawing by K. Jezierski)

II. 7. Ciąg geometryczny kół wpisanych w kwadraty o boku A. W drugim kroku centralne koło mierzące $1/2A$ zostaje wyznaczone i jest ono równe promieniowi a (oprac. M. Barański, rys. K. Jezierski)



was astonishing, but the surprise deepened when I repeated the operation for circle A.

In the A-case the construction was inverted. Two circles of diameter A were drawn so that they touch at the capital's centre. The lower intersection of circle A with the capital's vertical axis supplied the apex of an isosceles triangle; from the upper intersection of the axis with the second circle A I dropped a perpendicular to locate the base of that triangle. When I joined the resulting base-points to the extensions of the larger square's sides, the full base-length of the isosceles triangle A emerged. Connecting the apex to those base-points left me speechless: the sides of the larger and smaller triangles coincide with the thicknesses of the stems visible in the drawing. One might have expected many things, but not so unambiguous a result. Even the greatest sceptic must concede that the principles of geometry are intertwined with the design of the Corinthian capital; this diagram is no accident but the product of a deliberate construction.

The construction itself is not confined to the capital block: it projects well beyond its outline and must have been worked out geometrically first, then reduced in scale and transferred to the working drawing of the capital. The inclination of the stem lines is determined by the sides of an isosceles triangle whose height equals fourteen abacus

units and whose base measures seven such units. When that inclination is carried onto the capital it appears as the hypotenuse of a right triangle whose legs are 7 and 1.75 abacus units – or, expressed differently, 7 units and $7/4$ units.

Delving still further into the geometry, I prepared a series of additional diagrams, this time to test the possible deployment of the irrational quantities $\sqrt{2}$ – the diagonal of a square – and $\sqrt{3}$, which arises in the height of an equilateral triangle, together with the next term $\sqrt{4}$ (Fig. 9). The constructions were laid out on one-half of the sides of squares A and B. Many of the points thus generated had already surfaced in the work with equilateral triangles, where – as noted – there is a close correspondence between the height of the A-triangle and the diameter/side of the B-circle-and-square.

A particularly instructive result emerged for the segment $1/2B$. If the diagonal $1/2B\sqrt{2}$ is “folded down”, it fixes the level of the lower acanthus leaves – the very height previously determined by the vertices of the hexagon. The test was repeated with the half-diameter of the smaller circle – the distance that, as we have seen, governs the lower-leaf height. The diagonal of the square on that half-diameter intersects the capital's axis at roughly the depth of the initial inward curl of the central blossom. By contrast, setting off the longer irrational $1/2B\sqrt{3}$ gives the now-familiar

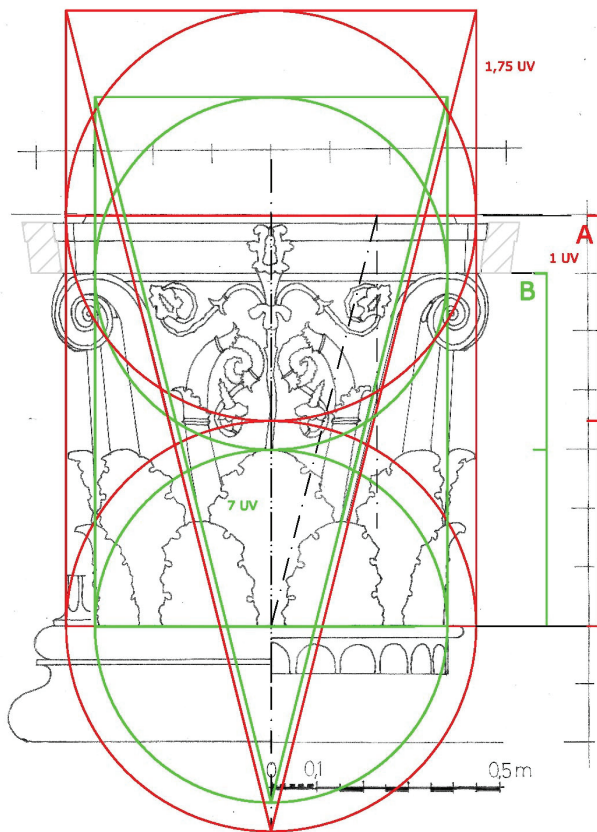


Fig. 8. Geometrical construction of two circles A and two circles B designates both an angle of a corner stem leaning, as well as thickness of a stem edge (elaborated by M. Barański, drawing by K. Jezierski)

Il. 8. Geometryczna konstrukcja dwóch kół A i dwóch kół B wyznacza zarówno kąt pochylenia narożnych łodyg, jak i grubość krawędzi łodygi (oprac. M. Barański, rys. K. Jezierski)

characteristic point: the apex of the small equilateral triangle. Pushing one step further, $1/2B\sqrt{4}$ closes at the underside of the abacus, completing the square constructed on the upper shaft diameter.

An analogous exercise was carried out for half the larger diameter. The segment $1/2A\sqrt{2}$ marks the upper run of the intermediate volutes and the seating of their outer stalks. Extending to $1/2A\sqrt{3}$ yields a point very close to the diameter of the subsidiary circle and almost coincident with the height of equilateral triangle A (the calathus height is 77.4 cm, whereas the computed apex of the A-triangle is 78.1 cm – a divergence of about 0.7 cm, slightly larger than one would wish, an average error is 0.9%). Plotting $1/2A\sqrt{3}$ revealed that the arc so described cuts the volute centres; that same arc is also intersected by the line that constructs $1/2A\sqrt{4}$, and it lies almost exactly on the volute centre derived from $\sqrt{3}$ of the smaller circle. Reversing the $\sqrt{2}$ operation on the side B again located the lower-leaf level, but performing the same reversal on the side A produced no significant result.

During the course of the investigation the golden-section principle was also put to the test. Plato describes that proportion, calling it aesthetically perfect (Plato 2016, *Timaeus* 31c–32a); Euclid sets out its construction in Book II, Proposition 11, naming it “the extreme and mean ratio.” The

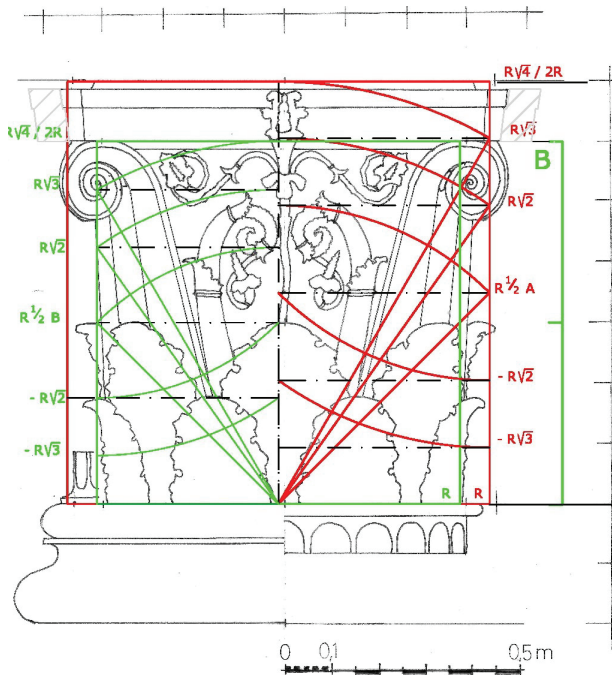


Fig. 9. Characteristic points of a capital are related to progression of a side equal to radius (R) of circles A and B by a root of 2, 3, 4.

Minus “-” marks inverted progression
(elaborated by M. Barański, drawing by K. Jezierski)

Il. 9. Charakterystyczne punkty kapiteła odnoszą się do postępu kwadratu, sześcianu i czwartej potęgi budowanego dla promienia (R) kół A i B. Minus „-” oznacza odwrócony postęp
(oprac. M. Barański, rys. K. Jezierski)

ratio was examined for the capital’s height by constructing a right-angled triangle whose shorter cathetus measures $1/2A$ and whose longer cathetus equals A . The shorter side proved to correspond, more or less, to the side of the abacus slab as fixed by Vitruvius’ rule. When the golden division was marked on the hypotenuse, the point obtained coincided with the level of the upper acanthus leaves – a level that, in any case, results from halving circle B. A parallel test on the right-angled triangle constructed for dimension B yielded no significant result.

This analysis therefore produced no conclusive evidence, although one must remember that the golden ratio can arise in other configurations, notably within the pentagon. Given the paucity of ancient sources, it remains difficult to determine which additional constructions were actually familiar in the Hellenistic period (Fowler 1999, 84, 85); many of the more elaborate procedures were introduced much later, some in the 20th century.

Here the difficulty arises of deciding which geometric constructions were actually known in the Hellenistic period and which were introduced only later, even in modern times. Geometrically, the golden ratio can be demonstrated in a right triangle whose sides have the requisite lengths; by operating on a square and taking the diagonal of one of the rectangles obtained by halving it; by forming a right triangle whose vertices belong, respectively, to a pentagon, a hexagon, and a decagon inscribed in circles of identical diameter; by a construction based on the sides of a pentagram; and – most recently – by a procedure derived from

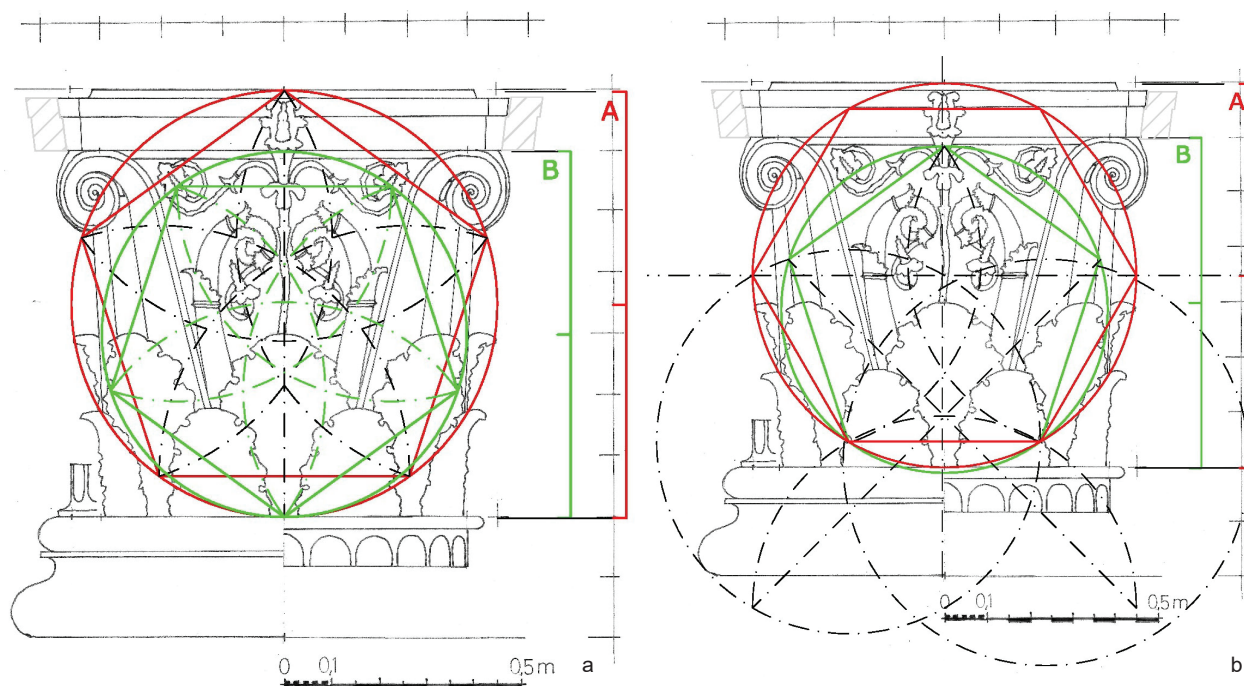


Fig.10. Geometric analysis of capital: a) pentagram inscribed into A and B circle. An upper corners of B pentagon designates centers of side flowers, b) side of hexagon inscribed into A circle is equal to a side of pentagon inscribed into B circle. Thus we can construct a capital scheme being on a line segment equal to $1/2$ of A circle or radius a . Circles A and B are in proportion 7 to 6, thus a differences is $1/7A$ and this is equal to abacus height (elaborated by M. Barański, drawing by K. Jezierski)

Il. 10. Geometryczna analiza kapiteła: a) pięciokąt wpisany w koła A i B. Górne naroża pięciokąta B wyznaczają środki bocznych kwadratów, b) bok sześciokąta wpisanego w koło A jest równy bokowi pięciokąta wpisanego w koło B. W ten sposób możemy konstruować schemat kapiteła będącego opartym o odcinek równy połowie średnicy koła A, będącym promieniem a . Koła A i B mają proporcje 7 i 6, co daje różnicę $1/7A$, a to jest równe wysokości abakusa (oprac. M. Barański, rys. K. Jezierski)

an equilateral triangle inscribed in a circle, first generated geometrically in 1984 (Odom, van de Craats 1986).

The last of these, together with the pentagram-in-a-circle diagram, is of particular interest in the present context: both represent further examples of figures inscribed in a circle, analogous to the hexagon and the square already considered. A full discussion of the golden section and its possible connection with the capital will demand a separate geometrical analysis, but it is worth emphasising here the simple case of an inscribed pentagon – a possibility not yet explored.

The pentagon – one of the forms employed in the construction of Platonic bodies – was next tested. A pentagon was inscribed in each of the two circles, A and B, that is, on the lower and upper shaft diameters. When the figures were set with their apices pointing upward they yielded nothing of particular interest. It is worth noting, however, that the arcs traced to generate the vertices of both pentagons A and B enter into special relationships that govern the outlines and positions of key elements in the capital's central ornament, the zone delimited by the circle of diameter $1/2A$ being equal to a radius a . A second diagram was drawn with the pentagons inverted, their apices turned downward (Fig. 10a). To my surprise, the base of pentagon B now established a horizontal line that links the stem of the central blossom with the centres of the lateral blossoms; indeed, the centres of those side blossoms lie exactly at the vertices of the same pentagon. The situation recalls an earlier result obtained with the equilateral triangle,

whose vertices located the centres of the corner volutes. The pentagon thus proves to be a useful figure, even though it identifies relatively few characteristic points. An intriguing question now arises: might the very act of inscribing a pentagon within a circle have been consciously exploited in designing a Corinthian capital? Was the pentagon itself a significant figure in the original conception? One further – and quite unexpected – feature of the geometry seems to support such a view. We recall that inscribing a hexagon in a circle produces a figure whose side equals half the circle's diameter, that is, the radius on which the hexagon is constructed. At first sight one would assume that no comparable relation could apply to the pentagons employed in the capital, for the side of a regular pentagon is by nature larger than one-half the diameter of its circumscribed circle. Yet a surprising equivalence emerges when the side of pentagon B is compared with one-half the diameter of circle A: the two measures coincide precisely (Fig. 10b). Such concordance can hardly be accidental; rather, it is the result of a perfect calibration between the dimensions of the two circles. We have here yet another instance of the way the entire network of figures – essentially generated from a single segment – locks together, taking full account of the special reciprocal relations between the circles that correspond to the lower and upper diameters of the column shaft.

Let us now return to our basic geometric operations and consider them in terms of rationality, irrationality, and the inter-relations of the figures. The first figure was an equilateral

triangle resting on the capital's base, its side equal to the diameter of circle A. That produced a second equilateral triangle inscribed in the same circle; its side is irrational, yet within that triangle one can inscribe a circle whose diameter is $1/2A$. A striking conjunction emerges: the vertical distance between the apex of the large triangle (side A) and the apex of the inscribed equilateral triangle is, to a close approximation, $1/7$ of the diameter of circle A – in other words, the abacus height. Both $1/7A$ and $6/7A$ are irrational magnitudes, but, as we have seen, $6/7A$ is the diameter of circle B. By further operations on circle B we can generate new figures that interlock successively within circles A and B.

Superposing two equilateral triangles in circle A produces a six-pointed star whose outer vertices define a hexagon with side $1/2A$; that hexagon can in turn accommodate, almost exactly, a square whose side is B. It is remarkable that, starting from a triangle with an irrational side, we obtain a hexagon whose side is the rational segment $1/2A$ – and that both triangles and the hexagon can each contain a circle of diameter $1/2A$.

Right-angled triangles inscribed in circle A, with the diameter as hypotenuse, yield two further constructions depending on the catheti chosen. In the first case the right triangle is half of the square inscribed in the circle; as per Plato's *Meno*, this square has an irrational side. Within it one can inscribe a circle of diameter $1/2A$, which recurs in the geometric progression founded on alternately inscribing circles and squares: in a circle of diameter $2a$ we inscribe a square of side $a\sqrt{2}$; within that square a second circle of the same diameter; and then a new smaller square and circle of diameter a .

A six-pointed star (and hence a hexagon) can also be obtained from the vertices of right-angled triangles whose hypotenuse equals A, whose shorter cathetus is $1/2A$, and whose longer cathetus is $A\sqrt{3}$. Combining two such triangles gives rectangles with one irrational side and one side $1/2A$, each rectangle admitting a circle of diameter $1/2A$; three such rectangles together outline a hexagon of side $1/2A$. A pentagon with irrational sides relative to circle A can likewise be inscribed in that circle, and further figures can be placed in circle B; each generates smaller but analogous forms and, with them, new relationships. The Hermopolis capital is therefore saturated with just such nested, mutually dependent configurations.

Conclusions

By working with two such schemata – the larger and the smaller, corresponding respectively to the lower and the upper diameter of the column shaft – the designer gained a range of options that could individualise any given capital. A further point must be stressed when we examine the geometry deployed in the diagrams discussed above: the figures employed mesh with one another, forming inter-locking constructions that seem to be the product of a deliberate manipulation of geometric relationships. The two systems based on the circles are displaced from one another by exactly half a unit of the abacus height; in other capitals additional geometric constraints may well have

dictated a different offset. The model adopted here embraces figures generated from circles, squares, triangles, pentagons, and hexagons. Constructed on the lengths A and B, these figures mark the characteristic points of the capital's ornament, and the model readily incorporates the irrational magnitudes that arise from them. Only after considerable time did I grasp what Vitruvius really meant when he described the method for determining the size of the abacus slab. At first I failed to grasp the import of the seemingly simple instruction that “two diameters of the circles form the diagonal of the square abacus”: it appeared to lack any concrete geometric meaning. Once I began to work routinely with geometric models – including recursive progressions – it became clear that Vitruvius' words are a practical shorthand for an entire sequence of geometric proportions generated from a circle's diameter and the square erected upon it. Measuring the size of the abacus by setting off a diagonal equal to two circle diameters signals that a circle can be inscribed within that square, and that within that circle one may in turn draw the square whose side equals the primary diameter. The same geometric logic underlies the scheme that fixes the inclination of the stems: there, too, we have an isosceles triangle whose height equals two diameters. Significantly, the basis for constructing that isosceles triangle is identical in form and dimension to the procedure used to establish the abacus size; the only difference lies in the location – on the capital's axis rather than on the diagonal. Nothing here is accidental or idiosyncratic: each element is a geometrically intelligible step in a single proportional sequence.

The inter-relations between circles A and B do not, by themselves, explain how the actual diameters were chosen – diameters that represent the lower and upper widths of the column shaft, or, in other words, the total height of the capital subdivided into abacus and *calathus*. The diameter of the smaller circle B can, of course, be derived from the larger circle A by a straightforward application of Thales' theorem; yet other methods are available. As we have already shown for the Hermopolis capital, the apex of an equilateral triangle whose side equals A – or, equivalently, the apex obtained by setting out $\sqrt{3}$ on the half-side $1/2A$ – falls almost exactly on the level of the abacus slab and thus determines the diameter of circle B. That construction yields a division that comes very close to the canonical ratio of one-seventh.

There is, however, an even more elegant way to obtain both circles at once in the desired 6 : 7 ratio. In this solution neither circle is derived from the other; instead, both are constructed simultaneously from a single chosen segment line (Fig. 10b). The key observation is that the side of the hexagon inscribed in circle A is equal to the side of the pentagon inscribed in circle B. On that basis one can devise a geometric construction that fixes the diameters of both circles by starting with a segment equal to the order-module – that is, the radius of circle A. The difference between the two diameters then corresponds exactly to one-seventh of the diameter of circle A. Recognising this dependence suggests that a dual system may have been developed, analogous to the method of locating the vertices of a hexagon by halving its side, or to the constructions that employ right-angled or equilateral triangles erected on half the diameter

– namely, the radius – of the fundamental circle. All regular geometric figures can be constructed from a single segment or line (Majewski 2013, 108–112, 116). But our study pointed out relations among figures inscribed into circles, being constructed this way, on a basic segment, a module responsible for a general architectural design, as well as governing decoration of a crucial element – a capital.

The geometric model here reconstructed for the Corinthian capital from Hermopolis Magna was subsequently applied to other, earlier Hellenistic capitals of a similar form – among them those of the Tholos at Epidauros (ca. 360 BC), the Asklepieion in Athens (ca. 350 BC), and the Propylon on Samothrace (ca. 260 BC). The preliminary tests confirmed that the same underlying principles were in force, even though the individual capitals reveal a different choice of geometric figures – a variation that appears to reflect their differing proportions. The earliest examples exploit the interlocking relations of the figures in quite a straightforward manner, whereas the later ones display the system in a more elaborated form.

The issue of geometrical concept applied to Corinthian capital design has to be discussed in a wider context. At that moment we can only mention it perfectly fits to Pythagorean philosophy, as well as achievements of ancient geometry of this age. The studies of Theatetus of Athens (417–369 BC)

explains concept of a chosen basal segment line (Król 2006, 173; 2015, 30, 53–59, 79–90). This idea seems to be a principle being used in a Corinthian capital design of Hellenistic period. Author is preparing currently a study “Early Corinthian Capitals and their geometry. A microcosm of Pythagorean perfection” explaining development of the concept.

Let us return once more to the capital’s proportions scheme as it described by Vitruvius. In the Hermopolis example, the ratio 6 : 7 defines the height of the abacus – precisely the difference between the lower and the upper diameters of the column shaft – exactly as Vitruvius describes 1:7. On the other hand, the lower diameter is the module of the order, the basis of every proportional scheme in a Greek temple. Thus it would be possible to define proportion scheme mentioning only partition of a main circle, but not of two units. Referring to two different units inevitably invites more error than working with a single measure. It is striking that our ancient author did not put the matter more simply – explaining a partition calculation as being based on a module only. In the source elaborated by Hellenistic architect, on which Vitruvius presumably relied, distinguishing the two diameters must have been crucial.

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References

- Adriani, Achille. *Lezioni sull'arte Alessandrina*. Libreria scientifica editrice, 1972.
- Asgari, Nusin. “The Stages of Workmanship of the Corinthian Capital in Proconnesus and its Export Form.” In *Classical Marble: Geochemistry, Technology, Trade*, edited by Norman Herz, Marc Waelkens. Kluwer Academic Publishers, 1988.
- Barański, Marek. “The Archaeological Setting of the Great Basilica at el Ashmunein.” *Journal of Roman Archaeology. Supplementary series* 19 (1996): 98–106.
- Barański, Marek. “Coloured Hellenistic Architectural Remains from El Ashmunein (Hermopolis Magna Egypt).” In *Colour in the Ancient Mediterranean World*, edited by Liza Cleland, Karen Stears and Glenys Davies. BAR Publishing, 2004.
- Barański, Marek. “Hermopolis Magna at the Crossroads of Cultures.” In *Greco-Roman Cities at the Crossroads of Culture*, edited by Rafał Czerner and Grażyna Czerner-Bąkowska. Archaeopress, 2019.
- Bassioni, Ahmed M. *The Alexandrian Corinthian Capital and its Role in the Evolution of the Corinthian Order in Hellenistic, Roman and Late Roman Architecture. A Comparative Study (3rd century BC–7th century AD)*. Archaeopress, 2022.
- Bauer, Heinrich. *Korinthische Kapitelle des 4. und 3. Jahrhunderts v. Chr.* Gebr. Mann, 1973.
- Beutelspracher, Albrecht, and Bernhard Petri. *Der Goldene Schnitt*. Spectrum Akademischer Verlag, 1996.
- Dentzer-Feydy, Jacqueline. “Remarques sur la métrologie et le projet architectural de quelques monuments d’époque hellénistique et romaine en Transjordanie.” *Studies in the history and archaeology of Jordan* 5, (1995): 161–71.
- Ebeling, Herman Louis. “The Origin of the Corinthian Capital.” *The Art Bulletin* 6, no. 3 (1924): 75–81.
- Fowler, Dawid. *The Mathematics of Plato’s Academy: A New Reconstruction*. Clarendon Press, 1999.
- Ghyka, Matila C. *Złota liczba: rytuały i rytmy pitagorejskie w rozwoju cywilizacji zachodniej*. Translated by Ireneusz Kania. Universitas, 2001.
- Hagenmaier, Otto. *Der Goldene Schnitt. Ein Harmoniegesetz und seine Andwendung*. Weltbild Verlag, 1977.
- Heilmeyer, Wolf Dieter. *Korinthische Normalkapitelle: Studien zur Geschichte der Römischen Architekturdékoratíon*. Kerle, 1970.
- Hesberg, Henner von. “Zur Entwicklung der griechischen Architektur im Ptolemäischen Reich.” In *Das ptolemäische Ägypten. Akten des Internationalen Symposions 27.–29. September 1976 in Berlin*, edited by Herwig Maehler, Volker Michael Strocka. Philipp von Zabern, 1978.
- Hobson, Ernest William. *Squaring the Circle. A History of the Problem*. Cambridge, University Press, 1913.
- Hoepfner, Wolfram. *Hermopolis Magna das Heiligtum für Ptolemaios III. Eine Nachlese*, UVK Verlagsgesellschaft, 2020.
- Homolle, Théophile. “L’origine du chapiteau corinthien.” *Revue Archéologique* 2, (1916): 17–60.
- Król, Zbigniew. “Geometria starożytna i filozofia Platona na podstawie komentarza Pappusa do X księgi ‘Elementów’ Euklidesa.” *Kwartalnik Historii Nauki i Techniki* 51, no. 3–4 (2006): 169–203.
- Król, Zbigniew. *Platonism and the Development of Mathematics. Infinity and Geometry*. Instytut Filozofii i Socjologii PAN, 2015.
- Lawrence, Arnold Walter. *Greek Architecture*. Revised by R.A. Tomlison. Yale University Press, 1996.
- Majewski, Mirosław. *Szkice o geometrii i sztuce: sztuka konstrukcji geometrycznych*. Aksjomat, 2013.
- McKenzie, Judith. *The Architecture of Alexandria and Egypt c. 300 B.C. to A.D. 700*. Yale University Press, 2007.
- Naredi-Rainer, Paul von. *Architektur und Harmonie. Zahl, Maß und Proportion in der abendländischen Baukunst*. DuMont Buchverlag, 1982.
- Odom, George, and Jan Van de Craats. “E 3007, The Golden Ratio from an Equilateral Triangle and its Circumcircle.” *Problems and Solutions. The American Mathematical Monthly* 93, no. 7 (1986): 572.
- Pedersen, Poul. *The Parthenon and the Origin of the Corinthian Capital*. Odense University Press, 1989.
- Pensabene, Patricio. *Elementi architetonici di Alessandria e di altri siti egiziani*. “L’Erma” di Breitshneider, 1993.
- Plato. *Timaeus*. Translated Peter Kalkavage. Hackett Publishing, 2016.
- Pollitt, Jerome Jordan. *Art in the Hellenistic Age*. Cambridge University Press, 1986.

- Robertson, Donald Struan. *Greek and Roman Architecture*. Cambridge University Press, 1979.
- Ronczewski, Konstantin. "Les Chapiteaux corinthiens et variés du Musée gréco-romain d'Alexandrie." *Bulletin de la Société Archeologique d'Alexandrie*, no. 22, (1927): 3–36.
- Rossi, Corinna. *Architecture and Mathematics in Ancient Egypt*. Cambridge University Press, 2007.
- Saito, Ken. "Doubling the Cube, A New Interpretation of Its Significance for Early Greek Geometry." *Historia Mathematica* 11, no. 2 (22) (1995): 119–37.
- Scahill, David. "The Origins of the Corinthian Capital." In *Structure, Image, Ornament: Architectural Sculpture in the Greek World*, edited by Peter Schultz and Rolf von den Hoff. Oxbow Books, 2009.
- Scott, Dominic. *Plato's Meno*. Cambridge University Press, 2006.
- Toma, Natalia. "Carving a Corinthian Capital: New Technical Aspects Regarding the Carving Process." In *Asmosia X: Proceedings of the Tenth International Conference. Interdisciplinary Studies on Ancient Stone*, edited by Patricio Pensabene and Eleonora Gasparini. "L'Erma" di Bretschneider, 2015.
- Vitruvius, Marcus Pollio. *The Ten Books on Architecture*. Translated by Morris Hicky Morgan. Harvard University Press, 1914.
- Wace, Alan. "Hermopolis Magna." *Journal of Hellenic Studies* 65, (1946): 109.
- Wace, Alan John Bayard, Artur Hubert Stanley Megaw, and Theodore Cressy Skeat. *Hermopolis Magna, El Ashmunein: The Ptolemaic Sanctuary and the Basilica*. Alexandria University Press, 1959.
- Wilson Jones, Mark. "Designing the Roman Corinthian Order." *Journal of Roman Archaeology* 2, (1989): 35–69. <https://doi.org/10.1017/S1047759400010291>.
- Wilson Jones, Mark. "Designing the Roman Corinthian Capital." *Papers of the British School at Rome* 59, (1991): 89–150. <https://doi.org/10.1017/S0068246200009685>.
- Wilson Jones, Mark. "Greek and Roman Architectural Theory." In *The Oxford Handbook of Greek and Roman Art and Architecture*, edited by Clemente Marconi. Oxford University Press, 2015.
- Wilson Jones, Mark. "Accentuating the Calathus." *The Journal of Ancient Architecture* 1, (2022): 87–113.

Streszczenie

Koryncki kapitel z Hermopolis Magna (Egipt) i jego geometryczna analiza

W artykule zaprezentowano studium hellenistycznego korynckiego kapitelu (240 p.n.e.) z Hermopolis Magna w Egipcie. Witruwiańskie proporcje zostały potwierdzone tylko częściowo. Spowodowało to podjęcie analizy geometrycznej. Wykonanie geometrycznych diagramów potwierdziło, że projekt był efektem systemu kreowanego przez figury wpisane w większe i mniejsze koła odpowiadające dolnej i górnej średnicy trzonu kolumny.

Słowa kluczowe: kapitel koryncki, Hermopolis Magna, geometria starożytna