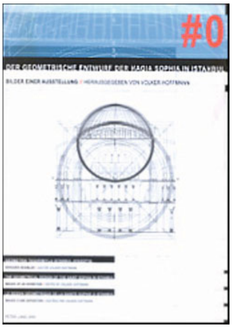

Keywords: Volker Hoffmann, Hagia Sophia, Byzantine architecture, geometric constructions, squaring the circle

Book Review

Volker Hoffmann

Der geometrische Entwurf der Hagia Sophia in Istanbul. Bilder einer Ausstellung

Bern: Peter Lang, 2005

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The publication reviewed here is only a slim volume and yet one experiences high expectations when picking it up. After all, it deals with an extraordinary architectural monument, and attempts to explain its technical and theoretic origins and background, which have often enough appeared to be veiled in mystery.

The Hagia Sophia in Istanbul is undisputedly one of the few outstanding masterworks of world architecture. Built in the sixth century A.D. by the Roman emperor Justinian, it still counts as one of the boldest human constructions to date. Although it has suffered repeated and sometimes serious damage, and its use has been modified frequently, it has still survived to this date with all its essential elements intact. Its broad, high-ceilinged interior space, which is roofed by seemingly weightless domes and vaults, never fails to make a striking impression on every visitor. However, it isn't easy to make the relation between the structural and design principles of this unique architectural system accessible, even to an expert. This effect was observed soon after completion of the church, and might even have been intended by the architects and their patron.

Volker Hoffmann has worked towards understanding the building principles and design processes of the Hagia Sophia throughout his long scientific career. An acknowledged scientist, Hoffmann taught history of art at the University of Bern up to 2005. With this publication he tries to illustrate how the architects of the sixth century geometrically developed the ground plan as well as the elevation of Hagia Sophia out of a single design figure. Hoffmann's theses, hailed as breaking discoveries (see, for example, [Staudacher 2004]), have been published elsewhere in parts [Hoffmann and Theocharis 2002] but, sadly, remain difficult for even specialists to comprehend. This publication, an exhibition catalogue and companion book in one, presents Hoffmann's positions to a broader public in a simpler, more understandable form and also augments them with general observations. This alone deserves our unreserved gratitude.

The book is a collection, in reduced format, of all the plates of an exhibition that first took place in 2005 in the Hagia Sophia in Istanbul and later in Berlin in the Kunstbibliothek der Staatlichen Museen. The forty-two plates, which are always positioned on the right hand pages, offer multiple pictures as well as short texts in German and Turkish. On the left side, translations of these texts in the English and

Nexus Network Journal 12 (2010) 531–535
DOI 10.1007/s00004-010-0044-2; *published online* 18 September 2010

French language have been added. The fact that these pictures are only included on the first pages and not repeated on the second, resulting in large blank above the English and French translations, is confusing only at first glance.

The introductory section of the publication (pl. 01-03) includes a report on how the exhibition was created, a list of all participating institutions and a short historical summary of the structure in question. Four thematic blocks follow to illustrate different aspects of the Hagia Sophia. The first block (pl. 04-15) collects some illustrations of the building under the title "Illustrations – Images". It includes a wide range of images, from the oldest, schematic illustrations of the tenth century to modern photographs and architectural surveys. The texts include the attempt to characterise the various ways of representing the structure, which Hoffmann had already presented elsewhere in greater detail [Hoffmann 1999]. Thus the emphasis in these texts is placed on older architectural survey material (pl. 08-13). On the other hand, the second part, entitled "Design – Groundwork" (pl. 16-33), is an extensive presentation of Hoffmann's theses on the geometric design of the Hagia Sophia. This constitutes the actual core of the publication. The third part focuses on "Construction and Deformation" (pl. 34-37) and illustrates some of the most important structural problems of the building. It also includes the various structural damage observed, as well as the corresponding repairs and modifications that have left visible marks on the building. The fourth and final part, entitled "Mathematics and Cosmology" (pl. 38-42), touches superficially on various aspects of intellectual history that supposedly support Hoffmann's theses.

The presentation seems befitting and entirely sufficient for the intended purpose of this exhibition. To a large extent, the text and illustrations appear well arranged and informative. To be sure, occasional mistakes show that not all aspects have been attended to with the necessary thoroughness. On pl. 08 for instance, the measurements from the drawings of Guillaume Joseph Grelot's 1670 survey are analysed, but the measurements used and discussed are not the ones found in the original 1680 edition cited but rather those found on the smaller illustration of the 1681 reprint, whose proportions have been extensively changed (cf. [Stichel 2008: 34-36, fig. 16. 21]. On pl. 35 "all the parts that were modified or added after 558" are presented in a clear and well-arranged manner. Yet this section contradicts the insights that Rowland Mainstone has offered the scientific world through his meticulous survey and its expert analysis ([Mainstone 1988]; cf. now [Duppel 2010]). On the same plate the suggestion by Henri Prost for the existence of three rows of windows, containing nineteen openings, on the walls between the main arches and the gallery of the Hagia Sophia is accepted. This blatantly contradicts the information handed to us by Paulus Silentiarius who, describing the building during Justinian's reign, clearly attests to eight windows without giving any information about the arrangement.

Nevertheless, the central thesis that was the reason for this exhibition is much more important than such smaller, diffuse details. Like others in the past, Hoffmann's design analysis also convincingly stems from the figure of a square (pl. 16-19) that lies almost completely hidden in the centre of the building between the main pillars, but has been laid out with great care and accuracy. This geometrical figure of a square is supplemented by "a circle inscribed in it and a circle circumscribed around it" (pl. 16), something Hoffmann calls an "analemma". Using the ratio of 100:106 the square is repeated slightly enlarged and the geometric system becomes a "double square with double circles" (pl. 16). This is Hoffmann's main design figure. Hoffmann then scales this "double-analemma" up and down by the factor $\sqrt{2}$ to describe the design processes (pl. 18). Based on this construction and, with the help of selected circles, he defines the building lines (in this publication referred to as "vanishing lines") for the exterior walls (pl. 18-19). Up to this point Hoffmann's thesis is clear and comprehensible.

Yet, according to Hoffmann, "the double-analemma is not sufficient to define all the construction relevant points and vanishing lines in the design" (pl. 20). Therefore Hoffmann develops the geometric figure further, which he, in a contrived and outmoded fashion, calls a *Mutterriss*, "master plan" (pl. 20). It is unclear how the rectangle that marks the building lines of the church (E1-E4) is developed from this master plan. Furthermore, this rectangle fails to define the building lines accurately. The deviation is visible even in the strongly scaled down ground plan. Indeed, this figure is absolutely insufficient to allow the development of the Hagia Sophia ground plan. Hoffmann therefore connects further points of the "master plan" without any recognisable system, and elongates the resulting lines to bearing lines. Their points of intersection have no significance for the ground plan, yet they partly lie on lines that approximately define the structure. Such a practice contradicts every architectural tradition and is not supported by historical sources. In addition, it is obvious that only very inaccurate results may be achieved by such a practice. At any rate it would have been very difficult for the architects of the Hagia Sophia to define the intersection points of these bearing lines clearly, especially since they meet at an acute angle, and even more so in a building of this size.

Hoffmann uses the "double-analemma" at various scales to also explain the elevation of the Hagia Sophia. At first glance the circular arcs match elements of the structure quite well. However, what the planar projection doesn't reveal is that these circles are positioned on different levels, the only reason why this geometrical system manages to appear so intriguingly simple.

All necessary criticism aside, Hoffmann did succeed in noticing one essential property of this structure that lies hidden in the central double square. With little difficulty it becomes apparent that the two squares of the so-called analemma are intimately connected and defined by certain clear proportions (pl. 38). The length of the side of the larger square equals 3/4 of the diagonal of the smaller square, while the length of the side of the smaller square equals 2/3 of the diagonal of the larger square. Hoffmann's postulate that the architects of the Hagia Sophia knew about "circling the square", i.e., the reversal of squaring the circle, should be read in a similar context. To this end, Moritz Cantor is cited but apparently only superficially so. Otherwise it should have become clear to Hoffmann that, in the field of applied mathematics of antiquity, irrational values were usually approximated by integer values whenever possible. As has recently been demonstrated, such approximations may be used successfully to explain the design of the Hagia Sophia in concordance to contemporary mathematics and philosophy [Svenshon and Stichel 2006; Svenshon 2010].

By choosing the ancient Greek "analemma" to describe his geometric figure, Hoffmann suggests that his method is based on ancient practice. This is highly misleading, since the actual analemma, especially as described by Vitruvius and Ptolemaeus, is a geometric figure with a significantly different form, as can easily be observed [Hübner 1996]. The weaknesses of the last part of the book seem to be of a similar nature. There Hoffmann tries suggestively to frame the design system against a larger humanities-related background. Aside from inaccuracies (pl. 40: an octagram is not a cube), statements that are simply false appear in this section. Hoffman claims that:

> in Greek and Roman culture, as well in the 6th century in general, we find two notions of the Cosmos, which either compete with or supplement each other: cube and sphere. … Sphere and cube, combined to one world model, symbolizing both world shape and world order, form the central design model of the Hagia Sophia" (pl. 40).

Of course it is correct that the ancients understood Earth and the Universe as spheres and that competing models for the cosmos existed. Yet the cube has never played a role as a cosmic symbol. Might it be that in this instance Hoffmann's terminology is confounded? At any rate, some theories of the time describe the physical form of the earth as "tetragonos". Yet this never suggests an actual square but rather an oblong form. It is also a completely different matter when Plato uses the cube as a symbol but not as an actual physical image of the element of Earth, while he appoints other regular geometric bodies to the elements of Fire, Water and Air. Hoffmann mentions the writings of Kosmas Indikopleustes, but does so selectively; Kosmas Indikopleustes aggressively accuses the spherical model of the Cosmos of being a pagan theory and decides therefore that it is a false model. On the other hand John Philiponos, one of the most essential scientists of the sixth century A.D., adopts exactly what Indikopleustes declines and confirms it through biblical arguments, something that Hoffmann seems to ignore.

In conclusion, one has no choice but to feel disappointed by the highly acclaimed results of Hoffmann's research. "The secret of the design principle used in the Hagia Sophia" has by no means been "uncovered" as previous enthusiastic commentators have claimed [Staudacher 2004]. Factual errors and insufficient research characterise essentially every thematic section with an intensity that undermines the scientific value of this publication in its entirety (as previously noted by Felix [2006]).

In the overall assessment it should not be overlooked that Hoffmann has achieved an exact survey of the Hagia Sophia using a Leica Scanner Cyrax 2000. Thankfully, the modern method attests to the "extraordinary exactness" of Robert Van Nice's survey, carried out using traditional methods and published some decades ago [Van Nice 1965–1986]. The irregularity of the ground plan in the area of the north-east conch that Hoffmann believed to have found in an older contribution [Hoffmann and Theocharis 2002: 419, fig. 23] proves therefore to be groundless. It is understandable that only small parts of this important survey, which offers the opportunity to describe every point in this structure with exact coordinates, may be included in this publication (pl. 14-15). It would of course be very helpful if the data of this undertaking could be made available in an appropriate form for the scientific community dealing with the Hagia Sophia. If this were done, the merits of Hoffmann's work, for which he has undoubtedly deserves credit, might also receive the wider attention they deserve.

English translation from German by Dr.-Ing. D. Boussios

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