Chapter 1 – Introduction: The Octagon in Late Antique Architecture

The development of the octagonal church in Later Antiquity owed much to earlier Roman architecture and architectural practice. From governing theoretical principles of design to the practicalities of laying out the plan of a building in preparation for construction, the octagonal churches continued traditions established long before they came into being. Understanding these principles and the formal ties to Roman architectural design and the use of similar designs in other Roman buildings will provide a solid background to their application in the churches under consideration here.

A critical element in understanding any architectural design and building process is that of measurement. Knowing a building's measurements as given in the modern unit of measurement of meters provides a certain level of knowledge of size and scale, but tells us nothing about the process used by those who designed and built these structures in the fourth through the sixth century. As it turns out, builders in this period used two types of feet as standards, known today as the Roman and the Byzantine foot (hereafter RF and BF, respectively). Typically, the Roman *pes* or foot is cited as being the equivalent of 0.296 m, but it has long been recognized that there are variations in this unit that range from 0.294 to 0.299.[1] The foot was divisible into either 12 *unciae* (inches) or 16 *digiti* (digits). For the Byzantine *pous* or foot, which begins to replace the Roman one in the third decade of the sixth century, the most commonly stated equivalent is 0.312 m, but this can also vary with the most common variant for the sixth-century buildings examined here being 0.32 m.[2] It, too, was divisible into 16 *daktyloi* or digits. The cubit, equal to 1.5 feet, and divisible into 24 *digiti* or *daktyloi*, was also used throughout Late Antiquity.

In designing buildings, Roman architects showed a marked preference for using round numbers divisible by 10, or sometimes 12 and occasionally 16, in the major measurements, particularly in the exteriors. This is what Jones called the "critical measurement", noting that units of feet or cubits of 50, 100, and 150, were especially popular.[3] In his study of central plan Roman buildings he noted that if the design of the building emphasized its exterior, then it was often the outer dimensions that would use such round numbers. So, for example, the Mausoleum of Augustus was laid out in a circle 300 RF in diameter. If the building's design focused on its interior, then the main interior dimensions would usually be in round numbers. This is seen in the interior diameter of the fourth-century Mausoleum of Constantina (Santa Costanza) in Rome, 75 RF or 50

1 Shilbach, *Metrologie*, 13–16 gives it as 0.296 m; Rottländer, *Lägenmasse*, 17 and 74, extends the digits to 0.29617; Jones, *Principles*, 74, notes the wider range as well as the fact the two different values for the foot are sometimes found in the same building. Parsons, *Engineers*, 625–26, puts the ancient Roman foot at 0.2995 m.

2 Shilbach, *Metrologie*, 13–16 gives it as 0.312 m; Underwood, "Principles," 65, suggests 0.315 m.

3 Jones, "Design," 117; for the sixth century see Underwood, "Principles," *passim*.

cubits.[4] In another observation with important implications for the design of the octagonal churches, Jones also noted that some centrally-planned buildings have more than one ring and that both the inner and outer rings with their architectural features could be set out using round numbers and "be simply related to each other."[5]

In preparing a site for the construction of a building, techniques and tools close to those used in land surveying were employed. The plan of the building would be marked on the ground using a *schonion* or rope of thick hemp and a measuring rod. Roman surveyors used the *decempeda* or *pertica*, a rod 10 feet in length with a bronze cap marked in *digiti*; later on, the Byzantine rod, the *orgyia*, was about 2.1 m or 108 *daktyloi* long.[6] The rope was used to layout longer walls, or affixed to a stake, to mark circles as needed (Fig. 1.1). The rods were employed for measuring smaller architectural features or put end to end to measure longer lengths.

These tools were used to lay out the octagonal plan of the churches being studied here. An octagon is a polygon of eight equal sides with eight angles of 135°, easy to draw because it is equal to 90° + 45°. There are several ways to draw an octagon, whether on paper or on the ground. One method involves starting with drawing a square, the sides of which are equal to the intended width of the octagon, measured between two facing sides (Fig. 1.2). Once the square is laid out, lines are drawn from each corner to its opposite, making an X in the square; where the lines cross is the middle point of the square. In laying out a building, a stake is put into the ground at that point and, using a rope, a circle is drawn with its radius being the distance between the center point and the corners of the square.[7] Once the circle is drawn, lines parallel to the sides of the square are drawn through the center point of the square to the circle, forming a + and extended outwards to touch the circle in four points. Finally, the sides of the octagon are drawn by connecting the eight points where these lines cross the circle with the corners of the square. If the sides of the square measured 50 feet, the length of its diagonal and the diameter of the circle as well as the octagon would be 70.7 feet.[8] To draw a larger, second octagon for a double-shell octagon plan, the surveyor simply had to extend the lines of the X and the + and then draw a second circle at the desired diameter.

A simpler method would be to start by deciding the middle point of the octagon, placing a stake there, and attaching a rope to mark out a circle of the desired diameter (Fig. 1.3). Since the length of each side is the same and most of the octagons were laid out with a diameter of a round number divisible by ten, a simple chart or table would give the surveyor the known length for the side measurement.[9]

4 Jones, *Principles*, 214–16; "Design," 112.

5 Jones, "Design," 114.

6 Taylor, *Roman* Builders, 64–56; Snesanay, "Technology," 154; Ousterhout, *Builders*, 60.

7 Paul the Silentiary wrote that Anthemios, one of the architects of Hagia Sophia, was particularly good at determining where such centers should be marked. See Chapter 8, note 14.

8 Shalev-Hurvitz, *Holy* Sites, 179–80, suggests this method and notes that many rotunda buildings have an inner diameter of 70 feet, indicating that their builders employed it. Very few of the octagonal churches have a diameter of 70 feet, as will be seen.

9 The idea of tables was suggested by Shalev-Hurvitz, *Holy* Sites, 180. I prepared the table by using the octagon calculator at https://rechneronline.de/pi/octagon.php (last accessed Jan. 31, 2017) to determine the side lengths and then converted those into feet and *digiti*/*dactyli*.

Diameter in feet	**Length of side in feet (p) and** digiti/dactyli **(d)**
20	7 p 10 ½ d
30	11 p 7 ¾ d
40	15 p 5 d
50	19 p 2 d
60	23 p 0 d
70	26 p 12 ¾ d
80	30 p 10 ¾ d
90	34 p 7 d
100	38 p 4 ¼ d
120	45 p 14 ¾ d

Knowing the length of the sides of the octagon based on its diameter, the surveyor could simply put his stake into the circle at any point and, using his rope marked at the appropriate side length, mark the circle at the point the desired length met the circle, place another stake at that point, and repeat the action until returning to the starting point, having marked the eight angles of the octagon. To make a second, larger octagon, the rope would be attached to the center stake and extended out to each corner and beyond to the desired half diameter to mark the corners of the exterior octagon. The process could be further simplified by starting any octagon with a radius of 30 feet or more by locating the center point for the stake and drawing a circle of 60 feet in diameter. The length of the side of an octagon this side would be an even 23 feet, so using a stake to set a point in the circle and drawing an arc with a length of 23 feet would designate two of the octagon's corners, and repeating the action would yield the other six corners. To make a second, larger octagon at this point the rope simply needed to be extended from the center point through each of these marked corners to whatever length – 40, 50, 60, 70 feet …. to mark the corners of the desired sized octagon.

The critical measurement of an octagonal building is its diameter, or in the case of the double shell octagons employed in most of the churches under consideration here, the diameters of the both the inner and outer octagons, and in a few cases, of the three octagons forming the basic design. In previous scholarship on these buildings a diameter is often included in the discussion, but it is not always clear which diameter is meant. Sometimes it is apparent that a person is actually referring to the width of an octagon as measured between facing sides. This measurement, however, is always going to be shorter than the diameter of the octagon when the angles are included, but in these cases, too, it is not always clear if a writer is referring to the diameter as measured from the inner side of the corners or their outer side, including the wall or stylobate of the octagon in question.

Returning to the process of laying out an octagonal structure, the question is what did the builder do after having set out the eight corners and sides of the octagon? Did he put the stylobate or wall on the outside of his marks, so that the marks determined the

inner diameter of the octagon? Or did he place his structure on the inside of the marks, so that they had determined the outer diameter? Or, in laying out a ground floor inner octagon that was going to be composed of piers and/or columns, did he use the marks to determine the placement of the center of the stylobate and its columns and piers? It turns out that all three methods were used to some degree. Outer octagons in double shell designs were almost always placed inside the circle defining the diameter, which is to say the diameter is measured from exterior corner to exterior corner. Most inner octagons were laid out in the same way, inside the circle circumscribing the stylobate. In a few cases, the round number diameter of the inner octagon marks the center of its stylobate and therefore the centers of its columns or it marks the centers of its corner piers. Rarely is the critical measurement round number diameter the internal diameter or the width of the octagon.

The reason that the outer dimension is the key one in the design of an octagonal structure becomes obvious upon reflection. On the one hand, the architect or builder does need to consider the interior span that will be covered by a dome or pyramidal roof. This is not, however, the only consideration, as that roof is likely going to be supported by a drum or short wall and the thickness of that support must be taken into consideration. The inner diameter measurement gives no indication of the thickness of the wall supporting the covering. The outer diameter measurement, or at times a measurement to the center of the piers or columns of the inner octagon, does account for it.

Determining the diameter of the circles used in the layout of the octagonal churches studied here meant first discovering the unit of measurement employed. This was done by checking not only the larger measurements of inner and outer corners of the octagon, but also measurements of architectural features such the width of door and window openings. Whether or not a Roman or a Byzantine foot was used and which variant within those groups becomes clear after a number of such measurements are taken and converted. For example, if a room is 5.92 m wide, that measurement is exactly 20 RF wide, using 0.296 m = 1 foot, but 18 ½ BF wide using 0.32 =1 foot; obviously, the unit used was the Roman, not the Byzantine, foot and it is confirmed by other measurements in the building. With very few exceptions, once the correct unit of measurement is determined and applied to the diameters of the buildings octagon or inner and outer octagons, the resulting calculation is a round number divisible by ten.

This is not to say that every building was laid out and constructed to exact measurements; a few were but more often than not the measurement is off by a few centimeters. Therefore, it might be determined that the actual measurement of a diameter might be 29.7 or 30.4 feet, but the intended measurement was clearly 30 feet. This lack of precision is well known in Roman architecture. As Jones noted, such variations in measurements are normally to be expected of up to 0.5 per cent for medium and longer distances.[10] In almost every case the actual measurement is close enough to its intended number that there is no question as to what the ideal design was.

In laying out octagonal churches, builders in late Antiquity were using methods that had been used in Roman architecture going back at least to the first century B.C.[11]

10 Jones, *Principles*, 71–72 and his list of centrally planned Roman buildings (214–20) shows most diameter measurements off 3–6 cm from their intended measurements. See also Taylor, *Roman Builders*, 66–75.

11 De Angelis d'Ossat, "Edifici," gives a brief survey.

Octagons were employed in many types of Roman buildings, from bath complexes to villas and palaces, most notably in the octagonal hall in the Golden House of Nero. None of these had any particular religious function or symbolism that would transfer to Christian places of worship. The octagonal building was not a type that was adopted to temple design, except in the northern parts of the empire were a few examples were found in Germany and England.[12] These are mostly fourth-century examples and likely had no influence on the Christian use of the type.

A more relevant use of the octagonal form for our purposes came about in its adoption as a form for tomb design. Though its use in Roman funerary architecture remained very limited, it can be documented as early as the first century AD in a freestanding octagonal tomb in Pula.[13] Some of the most important mausolea of the early fourth century employed an octagonal design. These included the Mausoleum of Diocletian (d. ca. 311) at Split in Croatia that still stands, having been converted into the cathedral of the city during the middle ages. In addition, the destroyed mausolea of Maximian in Milan, of Romula, mother of the emperor Galerius in Gamzigrad and that built for Maximin Daia at Šarkamen, both in Serbia, all were designed as domed, octagonal structures.[14] The form continued to be used in Christian imperial mausolea with that of the Valentinian Dynasty, now known as Sant'Aquilino in Milan of the second half of the fourth century, which was modelled on that of Maximian, but attached to the church of San Lorenzo.

The other relevant use of the octagonal plan during this period was in the design of many Early Christian baptisteries, starting with that built by Constantine at the Lateran.[15] Though not all baptisteries were built as octagons, many were throughout the Christian world. The reason for using this type is because of its link with funerary architecture: baptism, as St. Paul explained, was a kind of death and burial followed by a rebirth.[16] As will be seen, most of the octagonal churches of Late Antiquity were martyria, buildings associated with the place of death or burial of saints martyred for their faith. Therefore, the use of the octagonal plan in these churches was connected with the plan's use as a tomb type, just as was the case for the octagonal baptisteries.

The criteria used in choosing the buildings to be examined here were simple: the buildings must date from Late Antiquity, they must have an octagon as the core of their design, and they had to be independent structures or, in the cases in which the design expanded beyond an octagonal form, the octagon had to be an integral part of the larger design and the focal point of the church. Octagonal structures that are side chapels or appendages to larger churches have been omitted from consideration here. These include the octagonal chapels located on three sides of the church of San Lorenzo in Milan, and the octagonal chapel probably dedicated to St. Joseph near the Chalkoprateia basilica in Constantinople / Istanbul.[17]

12 See Koethe, "Rund- und Vielecktempel," and Horne and King, "Temples," passim.

13 Mirabella Roberti, "Notiziario."

14 For these buildings see Johnson, *Roman Imperial Mausoleum*, 50–86.

15 For the Lateran baptistery, Brandt, *Battisteri*, 33–85; in general, see Ristow, *Baptisterien.*

16 Romans 6:4; Colossians 2:12.

17 For the chapels in Milan, see Mackie, *Chapels*, 248–49; for the Chalkoprateia chapel, which if the dedication is correct was built by the Emperor Justin II (r. 565–78) and his wife Sophia, see Hennessey, "Chap-

A total of 35 octagonal churches including San Vitale have been identified and will be discussed.[18] Only three remain standing and in use – San Vitale, Sts. Sergius and Bacchus in Istanbul (now a mosque), and St. George in Izraa, Syria. The others are known from literary sources, from excavations, or because they were visited and recorded by some of the noted adventurer explorers of the nineteenth century. A few have largely gone unmentioned since those explorers first wrote about them more than a century ago. The majority of them are to be found in the eastern Mediterranean region, particularly in the Holy Land, Jordan, Syria, and Turkey (Fig. 1.4).[19] To the west, only three octagonal churches are found in Greece and in Italy, only San Vitale employs the form, though there are also two octagonal private chapels and one martyrium, and further west, a single private chapel of the form is found in Spain (Fig. 1.5).

At first impression, the number of octagonal churches is surprising, given that so few of them are routinely cited in scholarly literature concerning San Vitale. Upon further consideration when one contemplates the hundreds of Christian basilicas built in this period that are known, 35 seems a rather paltry number. The octagonal church in late Antiquity was a relatively rare phenomenon and speaks to the special character of San Vitale and its predecessors.

el." The chapel at Blachernae holding the relic of the Virgin's maphorion dating to the 460s, may have been octagonal, but this is uncertain. See Mango, "Origins."

18 The so-called Tomb of the Virgin in Jerusalem, the plan of which is often depicted as an octagon in older literature was actually a circular building, and so omitted here. See Shalev-Hurvitz, *Holy Sites*, 141–67.

19 I have included latitude and longitude coordinates for each of the churches so that they can easily be found on Google Earth. Some, both intact and in ruins, are easily seen in the satellite views. Coordinates are also given for the towns or cities where the destroyed churches once stood.