RESEARCHING THE ORIENTATION OF MONUMENTS
THE CHURCH OF THE GREAT METEORO MONASTERY

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Commission VI, WG VI

KEY WORDS: Surveying monument, geodetic and astronomical measurements, orientation.

ABSTRACT:

This work presents a method for the thorough research of the orientation of monuments, based on state-of-the-art geodetic and astronomical measurements. The proposed measurement and data reduction procedures are rigorous and lead to an accurate determination of the orientation of a monument. The term “orientation” collectively refers to: the astronomically oriented plan of the monument, the diagram of the perceptible horizon around the monument and the diagram of the apparent path of the Sun (or other star) as it rises above the horizon at characteristic dates. Then, the orientation is interpreted in terms of other, mostly cultural, information about the scope of the monument and in combination with its time of construction. In retrospect, therefore, the proposed method provides a new, independent way for the confirmation or the determination of the time of construction of the monument within a narrow chronological range.

An analysis of the method is given (including geodetic and astronomical observations and data reduction). The presentation of the method is best illustrated by the parallel discussion of a particular application, at the church of the Great Meteoro Monastery (within the “Meteora Monastic Community” in Central Greece). The performed measurements are described, accompanied by the corresponding geometrical diagrams. The orientation of the church is discussed in connection with the celebration date at the time of construction. Finally, useful conclusions are drawn about the geometrical characteristics of the monument and the meticulous attention shown by its constructors.

Application of the proposed method to other monuments is of great significance, since it will provide the geometric framework for a database of oriented monuments (in the form of a Geographical Information System), which will be very helpful for the study and preservation of our cultural heritage.

1. INTRODUCTION

The term “orientation” refers to the position and the direction (e.g. azimuth) of a monument at the site of its construction. Social or religious rules and traditions explain the relation between the orientation of the monument and the point of sunrise or the point where a star rises on a specific date. The solstices, the equinoxes or the date that the monuments celebrate have great significance for the builders. With regard to buildings, their placement, orientation, shape, material, the time of decoration, all give us important information about the cultural activities of a civilisation (Hoskin, 2001). Archaeoastronomy has delivered insights about the orientation of prehistoric and historical tombs, temples and other buildings worldwide. Several celestial bodies were used for the orientation of buildings in many cultures, the one mostly preferred among them being the Sun. This rule was already followed on Neolithic (Hoskin, 2001), Egyptian (Spence, 2000), Ancient Greek (Papathanasiou, 1994), Minoic and Mycenean (Liritzis, 2000) and Byzantine monuments (Pantazis, 2002).

Sunlight has been very important for Byzantine architecture. The natural light and the direction of illumination of the altar of a temple influence the choice of its orientation. Specifically, the orientation of Byzantine Orthodox Churches is determined by the illumination of the holy altar (Potamianos, 2000). The altar is of special importance in the Orthodox Church because the priest stays mostly there and performs the Holy ceremony, so its position is very well defined. All churches, as determined by tradition, should fulfill the proper illumination of the altar during the time of Eucharist. Generally speaking, according to Patrologia Greaca (4\textsuperscript{th} century AD) the recommended orientation for a church was set by the Holy Fathers to East – West (Migne, 1863).

2. METHODOLOGY

The method described in this work is based on the combination of the following procedures (Pantazis, 2002):

- The geometric determination of the main axis or of any other special direction of the monument, which is achieved by establishing an accurate geodetic network around the monument and creating its digital plan produced by accurate geodetic methods and instruments.

- The determination of the astronomical azimuth of a base of the network using observations of Polaris and transferring it, by geodetic methods, to the main axis or any other direction of the monument.

- The geometric determination of the boundary line (silhouette) of the perceptible horizon, as seen from a specific position of the monument, through geodetic measurements.

- The reconstruction of the apparent diurnal path of the Sun, or any other star, for characteristic dates (e.g. celebration day of the divinity to whom the temple is dedicated, solstice, equinox etc.) related to the time of construction.

Combination of the above data permits the determination and the interpretation of the orientation of a monument with the appropriate precision and reliability. There is also the possibility to date a monument according to its orientation with a narrow...
chronological range that depends mainly on the magnitude of the monument.

3. THE CHURCH OF THE GREAT METEORO MONASTERY

3.1 Historical Information

The "Meteora monastic community" is situated in the area of Kalabaka in central Greece. It is the second biggest group of Byzantine monuments in Greece. Today only six monasteries are open, from the twenty that had been erected there in a period of three centuries (14th to 17th) (Sofianos, 1990). The Great Meteoro Monastery is the biggest one and is founded at the top of a rock, 588 m above mean sea level. The main church of the monastery is dedicated to the Transfiguration of our Lord, which celebrates on August 6th.

The building is 25.8 m in length and 10 m in width. The frescos on the walls are dating from the 15th and 16th century. According to historical sources (Sofianos, 1990) the first small building, which was located at the place of the church’s holy altar of today, was erected in 1360 by Saint Athanasius the Meteorist, who was the first inhabitant of this rock. After his death in 1388, the monk Ioasaf enlarged the building and erected the big church that exists today. This church is the biggest of the Meteora monastic community and has all the main characteristics of the late Byzantine architecture. The building was constructed simultaneously with the main church, and, initially, it had some other use. Its length is 7.25m and width 5m. It was converted to a chapel after the completion of the big church.

3.2 Surveying the monument

A polygonometric network was established inside and outside the monument, in order to survey it for a scale of 1:50. This network consists of 12 points (figure 1) which are placed at appropriate positions in order to measure all the detail - points of the monument.

The elements of the network were measured using the method of the "three tripods", in order to eliminate the errors of centring and levelling of the instruments. The measurements of the detail points of the church were made using an integrated Total Station that measures without retroreflector and has a laser pointer, in order to mark each point accurately. The X, Y coordinates of each point of the monument were determined with an accuracy of ± 3 mm in the GGRS 87 (Greek Geodetic Reference System 87). The orthometric heights H of the points were also determined, with a little lower accuracy (about ± 1 cm). The digital drawing of the plan has all the details of the building. This plan is used for the determination of the main axis of the church, as well as for the extraction of any other geometric information of the monument. The final plan of the monument is presented in figure 2.

![Figure 1. The polygonometric network.](image1)

![Figure 2. The plan of the two Churches](image2)
the east of the church is presented in figure 3. The x-axis shows
the azimuth and the y-axis the altitude (in degrees and grads) of
the horizon. Picture 2 is the photographic documentation of the horizon.

3.4 Determination of the perceptible horizon

The perceptible horizon of a monument is of high importance
because it permits, or restricts, the view of the Sun and the
entrance of the sunlight in the holy altar. It is defined by natural
terrain, mountains, rocks, and sea or by buildings that already
existed at the time of construction of the monument.

Figure 3. The diagram of the perceptible horizon towards the
East

Measurements of azimuth and altitude of characteristic points
permit the creation of the diagram of the perceptible horizon.
The measurements were done from a point of the network in
front of the Altar. It is indispensable that all these measurements
refer to the middle of the Altar, so that the drawing of the
perceptible horizon corresponds to the view of the horizon from
the Altar.

The eastern horizon of the church is at a mean distance of
1000 m and the determination of its diagram was done with an
accuracy of 2 arcminutes, due to pointing uncertainties. The
adjustment was easily calculated, since the coordinates of the
points of the horizon, the network points and the altar were all
known from the geodetic network and the digital plan of the
church. The diagram of the view of the perceptible horizon to
the east of the church is presented in figure 3. The x-axis shows

3.5 Determination of the path of the sun

The determination of the apparent diurnal path of the Sun, as
seen from this monument and for a given date, was done using
the SkyMap Pro 8 software (digital almanac & virtual
planetarium, Marriot (2001)). Necessary input data are:
- The astronomical coordinates \( \Phi, \Lambda \) of the church (determined
  with satisfactory accuracy from the GPS measurements of the
  geodetic network).
- The date (any date between 4713 BC and 8000 AD) and the
time interval between successive points of the position of the
Sun in the sky.

A local ephemeris of the Sun was produced, listing altitude and
azimuth of the Sun, accurate to about 2 arcseconds (Meeus,
1991), as a function of local time.

The church of the “Transfiguration of our Lord” celebrates on
August 6th and the chapel of Saint John celebrates on January
7th each year. As already mentioned, the first building was
erected in 1360 and contained the holy altar of today and the
chapel. The extension of the building was done in 1388.

Therefore, the calculation of the path of the Sun was made for
these particular dates and years.

Figure 4 combines all available data, showing the path of the
Sun and the azimuths of the examined lines superimposed on
the diagram of the perceptible horizon. The rectangular insets in
the figure show, in magnification, the intersection of the three
characteristic lines and the resulting accuracy of the orientation.

4. DISCUSSION

As it is apparent from the diagram in figure 4
- The intersection of the vertical line, representing the azimuth of the main axis of the two churches, and the line of the perceptible horizon coincides with the point of sunrise on the 7th January 1368 ± 18 years. This agrees well with the year of construction (1360 AD).
- The intersection of the vertical line, representing the azimuth of the line inscribed in the marble stone, and the line of the perceptible horizon agrees well with the point of sunrise on the 6th August 1388, when the church was extended. This implies that the first building, which contains today the Altar of the “Transfiguration of our Lord”, was originally dedicated to Saint John the Baptist. This is in accordance with the traditional rule that the orientation of the church should be towards the sunrise on the celebration day of the Saint to whom it is dedicated. When the church was enlarged in 1388, the founders could not change the orientation of the building, so they placed this marble plate with the line in order to indicate the point of sunrise on the new celebration day when the church was dedicated to the “Transfiguration of our Lord”.

5. CONCLUSIONS

The combination of geodetic and astronomical data, measured using modern digital total stations, allows the determination of the orientation of a monument with high precision and reliability. Combining them with historical data referring to the time of construction, the final interpretation of the orientation of the monument may be achieved. Furthermore, there is also the possibility to date a monument by the proper combination of historical, cultural and geometric data (Pantazis, 2002), (Pantazis et al, 2003). This method may be useful for creating a database of oriented monuments, containing the geometric documentation of each monument, its orientation with the appropriate historical evidence, as well as historical documents referring to the monument. This database will be of great international importance.

6. REFERENCES


