Publ. Astron. Obs. Belgrade No. 91 (2012), 315 - 320 *Contributed paper*

ORIENTATION OF THE SERBIAN MONASTERY STUDENICA CHURCHES

M. TADIĆ

University of Belgrade – Faculty of Geography, Studentski trg 3/III, 11000 Belgrade, Serbia
E–mail: tadija2@afrodita.rcub.bg.ac.rs

Abstract. The edifice of the Serbian monastery Studenica embodies six mediaeval churches whose longitudinal axes are not parallel. Having in view the ecclesiastical canon which states that the axis is to be directed 'towards the sunrise', the dates when the sun rises over the real monastery's horizon, where the axis ends, were first determined; those are the most probable dates when the foundations for those churches were laid. The results were checked by means of direct observation, so that the exposed astronomical-geographic method may be applied in analysing the orientation of any mediaeval church.

1. INTRODUCTION

Professor Slobodan Nenadović (Nenadović, 2003) was the first expert to point out the need for a systematic study of longitudinal axes of mediaeval churches in Serbia. A potential approach for future studies is shown by the example of the Serbian monastery Studenica (43° 29' N, 20° 32' E), ranked in the UNESCO World Heritage 1986 list. Studenica was chosen because the monastery edifice encompasses six mediaeval churches, i.e. the katholicon (the Church of the Blessed Virgin) and five parakkleses (side chapels). Three parakkleses are within the monastery walls (the church of St. Joachim and St. Anna, the church of St. Nicholas, the church of St. John the Forerunner) (fig. 1), and the other two are 8-9 km upstream the Studenica river, part of the Lower and Upper hermit cells of St. Sava (the church of the Veil of the Mother of God, the church of St. George). All the six churches were erected between 1183 and 1314; the katholicon was built from 1183 to 1196, and the construction of each of the parakkleses lasted one year.

2. RESEARCH: ITS GOAL, TASKS, METHODS

It is generally known that the axis of an Orthodox church is to be set in the direction east-west (main entrance to the west, the altar in the east). The church canon, however, never states such a direction in mathematical-geographic sense (geographic azimuth 90°), but it simply sets forth that the church should be directed 'towards East' or 'in the direction of sunrise' (Mirković, 1966). It is not surprising, therefore, that one notices *prima facie* that the axes of the monastery Studenica churches are not parallel (fig. 1).

The canon, therefore, requires for an Orthodox church to be *oriented,* in the literal sense of the word. Acting according to the canon, a mediaeval master builder could proceed, when laying foundations for a church, in two ways: 1) direct the church axis towards the equinoctial east by aid of a gnomon or the North Star; 2) simply direct the church axis toward the rising sun on a certain day. The master builder did not violate any rule if the church axis is set in a sector of the horizon limited by solstitial points of the rising sun which, at mean geographic latitude of Serbia (44° N), is a section width of 67°.

Prior to analysing it, it is necessary to collect a range of data for each church: year (or at least, the century) when the construction of the church began, the church holiday (a saint or an event) to which it is dedicated, its donor-founder, the architectural style of the church, master builder (who he was and where did he come from). There are no complete data for any church of the Studenica monastery complex (tab. 1).

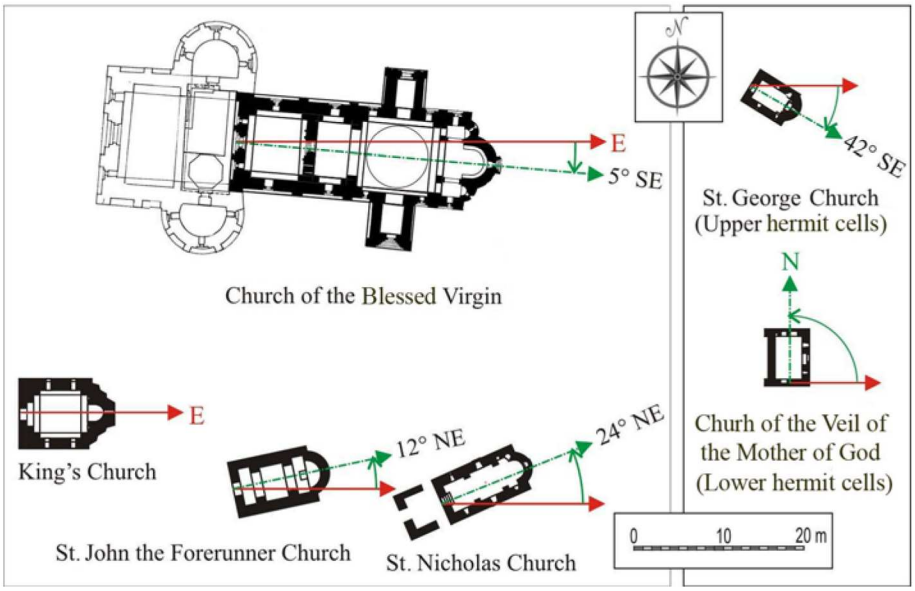

Figure 1: Aberration of axes of monastery Studenica churches from the eastern viewpoint.

After the facts had been gathered, the following was done for each of the Studenica monastery churches: 1) geographic azimuth of the church axis (A_N) was measured by gnomonic method (Tadić and Babić, 2010), i.e. aberration of the church axis from the eastern point (ΔA) (fig. 1), and the results were checked against measures on an aerial photograph; 2) on a corresponding 25 page a natural topographic profile along the church axis was constructed, and horizon coordinates were determined for the C point (A_N, h) where the church axis horizontal line crosses the real horizon; 3) after solving the problem – *Determine the declination of the sun* (δ) *when it is in the point C* (A_N, h)*, over the horizon* $T_0(\varphi_0, \lambda_0)$ – the astronomical ephemerides showed dates when the sun rises at point C, according to Gregorian (T_G) and Julian calendar (T_J).

Solution to those problems created conditions to answer the following two questions: 1) whether an aberration of a church axis from the eastern point has an astronomic or a liturgical sense; 2) what is the date (day, month) when the church foundations were laid?

3. RESULTS AND DISCUSSION

Direct measurements of the azimuth (fig. 1), and cabinet studies related to chart measures and spherical astronomy were done in 2010, and the on-site checks were performed on certain dates in 2011. The results are presented in Table 1.

Table 1. Churches of the monastery Studenica: basic data and measurements, and calculation results related to orientation

Church. Basic data	**Results**
Church of the Blessed Virgin. Erection of the church began in 1183. It is dedicated to the Ascension of the Holy Mother of God (Dormition of Virgin Mary, August 28). The donor was the Great Zhupan Stefan Nemanja. The church is in the Ras building school style. The master builder is unknown (it is surmised he was from 'the coastal region', most probably from Kotor).	$\Delta A = 5°\ SE$ $C\ (A_N = 95°,\ h = 12°\ 01')$ $\delta = 4°\ 40'$ T_G: 1. IV, 10. IX T_J: 25. III, 3. IX
Church of St. Joachim and St. Anna. It was erected in 1313/1314. It is dedicated to the parents of Mary the Holy Mother of God (September 21). The donor was King Milutin, and that is why it is also called **King's Church**. It was built in the Byzantine style, but the master builder is not known.	$\Delta A = 0°$ $C\ (A_N = 90°)$
Church of St. Nicholas (Nikoljača). Built by the beginning of the 13th century (before 1230). Dedicated to St. Nicholas (St. Nicholas' Day, December 19). It is a simple single-aisle construction with a semi-circular apse, with no distinguishing characteristics of a style. The donor and master builder are unknown.	$\Delta A = 24°\ NE$ $C\ (A_N = 66°,\ h = 10°\ 16')$ $\delta > \varepsilon_{1230} > 23°\ 32'$
Church of St. John the Forerunner. Erected in the 13th century, it is dedicated to St. John the Forerunner (St. John's Day, January 20). Once a single-aisle building with a semi-circular apse (probably with a vault). The donor and master builder are unknown.	$\Delta A = 12°\ NE$ $C\ (A_N = 78°,\ h = 11°\ 41')$ $\delta = 16°\ 41'$ T_G: 7. V, 6. VIII T_J: 30. IV, 30. VII
Church of the Veil of the Mother of God. Dedicated to the Veil of the Blessed Mother of God (October 14). A simple single-aisle rectangular construction, with a lodging facility leaning against the western wall. The donor and master builder are unknown. (St. Sava?).	$\Delta A = 90°$ $C\ (A_N = 0°)$
Church of St. George. It was built in the time of St. Sava and is dedicated to St. George (St. George's Day, May 6). A simple single-aisle rectangular construction with a semi-circular apse, with no distinguishing characteristics of a style. The donor and master builder are unknown (St. Sava?).	$\Delta A = 42°\ NE$ $C\ (A_N = 132°)$ $\delta < -23°\ 32'$

The axis of the church of St. George parakklesis is SE oriented, and it lies beyond the horizon of the eastern sector. Exact analysis is superfluous as the hermit cell is stuck against the vertical stone section, so that the master builder had no choice when laying foundations for the parakklesis.

Parakklesis of St. Joachim and St. Anna is on a levelled terrain. It is compass-oriented, with its axis directed exactly towards the eastern point of the mathematical horizon.

Parakklesis of the church of the Veil of the Mother of God is built on a rather steep slope. It is precisely compass-oriented, with its axis directed exactly along the south-north line (?), with its portal on the south side and the altar in the north.

The church of the Blessed Virgin was erected on artificially levelled ground. The church axis deviates by 5° from the eastern point towards SE (Tadić and Babić, 2010). When we take into account simple instruments and methods used by master builders for measuring and control in marking the basis for a foundation, and in erecting or enlarging the churches in the Middle Ages, we can say that all those who maintained eventually orientation accuracy within ±5° deserve a passing grade.

Parakklesis of the church of St. John is on a flat terrain. The parakklesis axis deviates by 12° from the eastern point toward NE. At the ultimate point of the extended church axis over the real horizon the sun rises on May 7 and August 6, according to the Gregorian calendar, i.e. at the time the church was built, on April 30 and July 30, according to the Julian calendar (Tadić and Petrović, 2011). Taking the first date as the most probable day when the building started (the beginning of the construction season), it is worth noting that one day before that date St. George's Day is celebrated (fig. 4).

Parakklesis of the church of St. Nicholas is erected on a levelled ground, almost parallel to the nearest part of the wall that surrounds the monastery. The parakklesis axis deviates by 24° from the eastern point toward NE. The sun never rises in that direction over the real horizon above the parakklesis, but the sunrise point for the summer solstice deviates by only 1.5°. It is safe, therefore, to say that the parakklesis was most probably determined according to the sunrise during the summer solstice (fig. 3). Pagan worship of the summer solstice was transferred onto St. John the Forerunner's Day (Janković, 1951), nowadays honoured on July 7, according to the Orthodox calendar (30 June 1230, according to the Julian calendar).

4. CONCLUSION

The edifice of the Studenica monastery has all types of longitudinal axes orientation for mediaeval churches.

St. George parakklesis is an example of a church the orientation of which was dictated by the configuration of the ground, when the master builder is exempt from all criticism. Orientation of the other five churches is linked to the sun geometry, where one could speak of the astronomical orientation.

St. Joachim and St. Anna parakklesis and the parakklesis of the Veil of the Mother of God are precisely compass-oriented. Axis of the first parakklesis is directed towards the eastern point of the horizon ($A_N = 90°$), with the portal on the western side and the altar in the east. The axis of the second parakklesis, however, is directed towards the northern point of the horizon ($A_N = 0°$), with the portal on the southern side and the altar in the north, which is not in conformity with the church canon. We can

safely say that their master builders were acquainted with the gnomon method (the Vitruvius's method) in determining the sides of the compass.

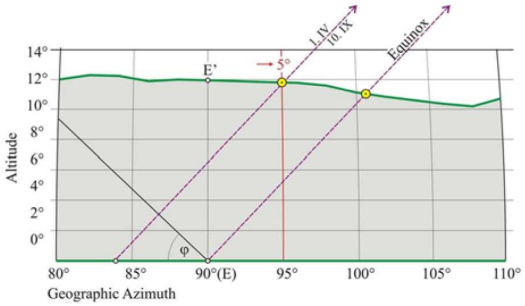

Figure 2: Part of the real horizon of the Blessed Virgin with apparent sun orbits (cross-sectional orthographic projection).

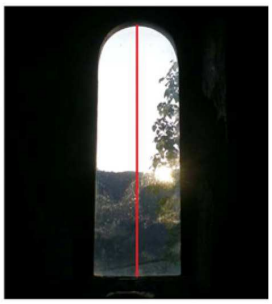

Figure 3: Sun rising on summer solstice 2011, viewed from the St. Nicholas church altar window.

Axis of the Church of the Blessed Virgin katholicon deviates by 5° from the eastern point toward SE and is within the aberration limits tolerated to mediaeval master builders. The axis is directed towards the point on the real horizon which is approximately in the middle between the eastern point ($A_N = 90°$) and the point of the real equinoctial sunrise ($A_N = 101°$), so one could 'stand up for' the Blessed Virgin church's master builder explaining that he, similar to what modern surveyors do in contentious cases, found a middle solution – he placed the church axis between the perpendicular to the meridian line, the latter determined by gnomon and spring equinox sunrise direction (fig. 2).

Parakklesis axis at St. Nicholas is directed approximately towards the summer solstice sunrise (fig. 3), so the parakklesis foundation was most probably laid down at the beginning of the longest day in the year. So that this parakklesis is also a sort of calendar: the appearance of the rising sun's rays on the church apse window marked the beginning of summer in its astronomical sense (Tadić and Gavrić, 2011).

Figure 4: The Studenica monastery, St. John church, 6^{th} of May, 2011 (St. John's Day), 6 h 38 min (GMT+2): the sun came out exactly on top of the extended longitudinal axis of the church.

The St. John parakklesis is connected directly to the geometry of the sun. If the master builder of the parakklesis directed its axis towards the rising sun, he did it on St. John's Day (fig. 4), while in pre-Christian times the Serbs celebrated the same

day dedicating it to the sun god, thus marking the beginning of the summer half of the year, and also the onset of the construction season (Janković, 1951).

With the exemption of the St. Joachim and St. Anna parakklesis, which has an exact equinoctial orientation, and whose patron saints are honoured on the very day of the autumnal equinox, the churches of the Studenica monastery do not appear to have a connection between their orientation and the church holidays (patron saints' days) to which they are dedicated, unless the St. John parakklesis was not originally dedicated to St. George only later to be renamed.

References

Janković, Dj. N.: 1951, Astronomija u predanjima, običajima i umotvorinama Srba (Astronomy in the traditions, customs and literature of Serbs) Српски етнографски зборник, LXIII; Друго одељење: Живот и обичаји народни, **28**, 69.

Mirković, L.: 1966, Pravoslavna liturgika ili nauka o bogosluženju pravoslavne istočne crkve I (Orthodox liturgics or science in the liturgy of the Orthodox Eastern Church I), Srpski arhijerejski sinod SPC, Beograd, 79.

Nenadović, M. S.: 2003, Gradjevinska tehnika u srednjovekovnoj Srbiji (Construction techniques in Medieval Serbia), Prosveta, Beograd, 485.

Tadić, M., Babić, S.: 2010, Orijentacija Bogorodičine crkve manastira Studenice (The orientation of Virgin church of the Virgin of the Studenica monastery). Zbornik radova nastavnika i saradnika Geografskog fakulteta u Beogradu, LVIII, 1–10.

Tadić, M., Petrović, A.: 2011, Mathematical-geographical analysis of the orientation of st John's church of the Studenica monastery. Zbornik radova Geografskog instituta "Jovan Cvijić", SANU, 61, 1, 1–11.

Tadić, M., Gavrić, G.: 2011, Matematičkogeografska analiza orijentacije dve ranohrišćanske crkve u Srbiji (A mathematical and geographical analysis of the orientation of two early christian churches in Serbia), Zbornik radova nastavnika i saradnika Geografskog fakulteta u Beogradu, LIX.