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Solar Alignments of the Planning of Angkor Wat Temple Complex

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Abstract: This paper is discussing some solar alignments that can be observed in the planning of the Angkor Wat temple complex in Cambodia. This complex was originally constructed in the early 12th century as a Hindu temple for the Khmer Empire and gradually transforming into a Buddhist temple. To illustrate the solar alignments we use SunCalc.net software and Photographer’s Ephemeris on Google Earth satellite images.

Keywords: Solar Orientation, Solstices, Azimuth and Zenith, Architectural Planning, Archaeoastronomy.

Angkor Wat is a large temple complex in Cambodia, originally constructed as a Hindu temple for the Khmer Empire, that became a Buddhist temple in the last part of 12th century. Khmer King Suryavarman II built the temple complex in the early 12th century [1-3], dedicating it to Vishnu.

Angkor Wat shows the two basic Khmer temple architectures, that is, the temple-mountain and the galleried temple. In fact, it is planned to represent the Mount Meru with its five peaks, but there are also three rectangular galleries, which are each raising above the other (see Figure 1 on the left) [3]. As remarked in [1], the building of Angkor Wat complex was an "enormous undertaking that involved quarrying, careful artistic work and lots of digging"; this undertaking required to solve several engineering problems for the stability of the structures. To support the temples, a tough material, the laterite, was used "which in turn was encased with softer sandstone that was used for carving the reliefs" [1]. Angkor Wat itself is surrounded by a moat that encompasses a perimeter of more than 3 miles; this moat was used for helping stabilize the temple’s foundation, “preventing groundwater from rising too high or falling too low” [1] (Figure 1 on the right).

Figure 1: On the left, aerial view of the central structure. Courtesy Shyam tnj, Wikipedia. On the right, the Angkor Wat surrounded by a moat used for helping stabilize the temple’s foundation [1]. Courtesy: Google Earth.
From the Figure 1 on the right we see an evident alignment to cardinal E-W directions, coincident to equinoctial sunrise and sunset directions. However, as observed in [4], unlike most Angkorian temples, Angkor Wat has its gate oriented to the west. In 1976, researchers of the Michigan University carried a comprehensive analysis of the role of astronomy and cosmology in the planning of the temple [5]. The Michigan researchers suggested in their paper that the architects of Angkor Wat had encoded calendrical, historical and cosmological themes into the architectural layout. As shown by [5], the researches demonstrated how Angkor Wat's architects had established solar alignments between the temple and a nearby mountaintop shrine that took place during the summer solstice (see Figure 2) [5]. In fact, twenty-two possible alignments had been identified and their relationship to bas relief and Hindu time cycles examined.

Figure 2: Alignment to sunrise on Summer Solstice of Angkor Wat and the Phnom Bok hill. Courtesy: SuncCalc.net and Google Earth. In SunCalc, a yellow straight line (here prolonged by the white line) gives the sunrise direction, a orange line the sunset. The curved yellow line is rendering the altitude of the sun.

The authors in [5] concluded that: 1. The rising sun appears aligned on equinox and solstice days with the western entrance of Angkor Wat; 2. The movements of the moon can be observed from a variety of positions within the temple, and lunar cycles may have been recorded in the three sets of libraries; 3. The bas reliefs of the third gallery can be understood in relation to the movements of the sun; 4. The measurements of the temple appear proportional to calendric and cosmological time cycles. Moreover, in [5], it was observed that, in the central tower, the topmost elevation has external axial dimensions of 189.00 Cambodian cubits east-west, and 176.37 Cambodian cubits north-south, with the sum of 365.37 [5,6]. This last figure is “perhaps the most outstanding number (in the Angkow Wat complex), almost the exact length of the solar year” [5,6]. However, as shown by Subhash Kak in his very interesting work [6], also the other two figures are remarkable: they are evidence of Vedic roots for the division of the solar year in Angkor Wat into two unequal parts. Kak tells that the inequality of the two dimensions with figures corresponding to the two parts of the year, a fact that the Michigan researchers were not able to explain, was not a mere accident but based on the ancient Indian astronomical knowledge [7].

Angkor Wat is also displaying a connection to the zenith passage of the sun, because the temple complex is located in the tropical zone [8]. A very interesting paper is in fact discussing the importance of zenith passage at Angkor Wat [9]; the authors, Edwin Barnhart and Christopher Powell, University of Texas, Austin, in August of 2010 and 2011 investigated this astronomical event on the site discovering, besides specific alignments,
that Angkor temples had vertical zenith sighting tubes to observed the zenith passage of
the sun or of other bodies of the celestial vault.
As we have observed for the planning of some architectures (Mughal gardens, ancient
Chinese towns and Buddhist complexes [10-16]), the architects had created in the
orientations and alignments of the layout of their works a reminder of the macrocosmic
order, representing on a local symbolic horizon the passage of time and the changing of
azimuth and altitude of the Sun at specific moments of the year. To investigate the
passage of the sun, in the abovementioned cases and in some others too, we used
Sollumis.com or SunCalc.net. The use of this last software (SunCalc) was first proposed in
[17,18].
Here we can repeat what we did on the Mughal gardens of Taj Mahal for Angkor Wat too,
to find specific alignments. Let us start from conclusion (1) in [5], that is: The rising sun
appears aligned on equinox and solstice days with the western entrance of Angkor Wat.
The alignment on equinox is evident from the Figure 1. The alignments of the gate to the
towers at the corners of the complex on summer and winter solstices are shown in the
Figures 3 and 4, where we used SunCalc.net software.

![Figure 3: Alignment to sunrise on Summer Solstice. Courtesy: SuncCalc.net and Google Earth.](image)

![Figure 4: Alignment to sunrise on Winter Solstice. Courtesy: SuncCalc.net and Google Earth.](image)
However, it is possible to observe also an alignment connected to the zenith passage of the sun. The alignment exists if we consider as locus of reference the central tower of the complex, the axis of which is in fact representing the axis Zenith-Nadir of the world. The alignment is given in the Figure 5. If we observe the Figure 6, which is obtained using the Photographer's Ephemeris, at the web page http://app.photoephemeris.com, we can see that it is also connected to corners in the pathway of the garden.

Figure 5: Alignments on a day of zenith passage of the sun (25 April). Courtesy: SuncCalc.net and Google Earth. The azimuth is about 76.2 degrees.

Figure 6: Alignments on a day of zenith passage of the sun (25 April). Courtesy: the Photographer's Ephemeris at http://app.photoephemeris.com and Google Earth. The azimuth is about 76.2 degrees.

As we have shown in [8,15,16], the zenith passage of the sun was quite important for people of Asia living in the tropical zone. We have discussed in [15], that the
archaeological complex of Sigiriya, the Lion Rock in Sri Lanka, has its axis oriented to the sunset of day of a zenith passage of the sun. Also the very important Buddhist religious center of Sanchi, has an alignment of stupas to the sunset direction of the day of the zenithal sun. In fact this alignment is to the sunset direction on the summer solstice [16,19], but because Sanchi latitude is close to the Tropic of Cancer, this is also the day of the zenith passage of the sun. Here we have seen that, also in the case of Angkor Wat, the zenith passage of the sun is marked by alignments and by the presence of specific structures for observations [9]. Let us note that, in the case of Angkor Wat, we observe alignments both for sunrise and sunset.

References