

Definition of Banteay Kdei's central axis using an Electronic Distance Measurement device

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1. Abstract

This paper explains the application of Electronic Distance Measurement devices in understanding the design of Khmer architecture, focusing in the orientation and alignment of the buildings.

2. Introduction

This research was carried out in the framework of the Sophia University Angkor International Mission efforts in studying, conserving, and protecting Khmer heritage.

Furthermore, this paper is based on a PhD dissertation completed in 2003, 'Etude de l'évolution architecturale et des techniques traditionnelles utilisées au temple de Banteay Kdei à Angkor' by the Author in the study of Banteay Kdei temple [Arahi, 2003]. It was carried out in a period of five years, under the guidance of Prof. Y. Ishizawa, Prof. K. De Jonge, Prof. K. Balen and Dr. B. Brugier.

3. Background

The design of Angkor Wat can be illustrated by reading its plan, the orientation in Khmer architecture is based on the definition of 2 perpendicular axes (north-south and east-west), the interception of these two axes defines a central point that actually corresponds to the architectural complex, from where, the secondly Perpendiculars and parallel axes are based. The geometry of the plan can be defined using mathematical formulas, such as the obvious application of the definite rule and cardinal principle.

Previous studies have already pointed out this matter. For example, Proskouriakova suggests that "the golden section" was used for making plans of Khmer monuments [Proskouriakova, 1999]. Mannika attempts to reveal the measurement system applied by the builders of Angkor Wat. According to her research, the lengths of each building of the temple are based on astronomical data composed of celestial ecliptic (the north-south oscillation of the sun, equinox and 30stice day etc). (Mannika 1997).

In addition, Dumont proposes a regulatory 'plan making' for Khmer architecture based on the geometric analysis [Dumont, 1996]. In this theory, Dumont -quotes the diagramed process for defining the north-south orientation using the solar movement (Fig. 1) by an Indian architectural text "Mayamalal" [Dumont, 1996 p.20]. This simplified method provides interesting alternatives to understand the construction process in Khmer architecture, although its application by Khmers builders remains uncertain.

Furthermore, Inoue has conducted an analysis of the central east-west running axe [Inoue, 2000] using the topographical map for Angkor archeological area made by JICA experts in 1997. This data has permitted him to obtain the degree of the east-west axis of 26 important Khmer Monuments Situated in Angkor. The points necessary for getting the degree of axis were digitized from the JICA's map using a tablet. This technique allowed identify the following issues: (See Fig. 2);

- The monuments built during the 9th -10th century (Prasat Prei monti, Bakong, Preah Ko and Indratataka) have a similar angle value. The axis of Banteay Kdei and Srah Srang almost correspond.
- Three monuments of the reign of King Jayavarman VII, including Angkor Tom, Preah Khan and North Baray have an

approximate value. This suggests that the orientation of three Bayon style monuments was defined using a similar technique

4. Banteay Kdei temple: understanding its orientation

4.1. The temple's relative Chronology

The relative chronology of the temple has been defined by a detailed recording of its architectural features, making emphasis in the identification of modifications, additions, connections in the stone masonry, wall junctions, and surface scraping.

Furthermore, this chronology has been improved by the typology examination:

- Comparing the motifs and ornaments in devatas, door frames, false windows, blind false windows, ridges, niches, etc.
- Layout and style of architectural elements, such as pillars, octagonal supports and door frames.

The conducted studies yielded two periods of construction, which are divided in several stages [Arahi 2003].

4.2. Understanding the orientation'. collecting information

In order to prove the orientation theories described previously, we attempted to define the origin of Banteay Kdei's axis orientation applying Inoue's method in each period of construction.

In addition to the data obtained in the relative chronology, we found several lines carved in the center of doorframes (Fig. 3), this might suggest that a marking system was used in the definition of the axes. It is important to mention that we have assumed that the missing marks on the doorframe have disappeared during the construction of the element or due to the action of weathering forms.

For the purpose of applying this concept and Inoue's axis definition method, we found the center of the door frames by the definition of the four edges, either by measuring in the bottom where visible or by projecting them from a profile.

Subsequently, 103 marks with a defined center were measured using an Electronic Distance Measurement device (EDM Total Station) (Fig. 4, 5). This survey was conducted during the 36th mission of Sophia University in Angkor last August 2003.

4.3. Understanding the orientation: processing collected information and results

Back in the field house, the surveyed marks were jointed in segments, each segment composed by two points was separately analyzed and an average angle was calculated (Fig 6). The addition of the different averages provided interesting results:

- The bearing of the segments connecting each building do not coincide with the main east-west axis.
- The variation ranges from 3.1 degree up 4.6 degree between segments.
- The bearing variation is even greater if two segments are defined from the center, to the east (4.07 degree) and to the west (4.53 degree).

5. Closing remarks

The buildings of the temple are not aligned using a single orientation as indicated in the Indian text. Further analysis of the results is required, the simplistic application of a single alignment is not correct; there might be other orientation techniques to be found.

6. Future activities

Control or the measurements taken by the Total Station should be performed using other alternative techniques (analogue theodolite, laser scanning, photogrammetry) to evaluate the integrity of the survey conducted. Application of the technique in other temples might be required.