Determination of the Geometric Form of Hierapolis Theater in Pamukkale, Turkey

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Abstract: This work addresses the issue of fitting a geometrical shape to the Hierapolis theater near the city of Denizli, Turkey. The aim of the study was to determine the geometrical shape of the theater that would best fit the set of measured site data points. The geometrical form of the theater was surveyed by using an electronic total station instrument. Because theater rings are generally elliptical in shape, the well-known ellipse-fitting algorithm was presented for computing the geometrical parameters. In this study, the authors plan to analyze the fitting algorithm presented, determine the best-fitting geometrical shape (e.g., an ellipse, a circle) to the Hierapolis theater, and characterize its features. Because the fitting accuracies are not sufficient to decide which geometrical shape is appropriate, a statistical testing procedure was applied to identify statistical differences between the related geometries. The most probable geometrical shapes for this purpose were determined with the use of the statistical equivalence test. DOI: 10.1061/(ASCE)SU.1943-5428.0000129. © 2014 American Society of Civil Engineers.

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Introduction

Hierapolis was one of the most important Hellenistic-Roman cities in Asia Minor. Located about 250 km east of the city of Izmir, the area is a UNESCO World Heritage Site because of its magnificent archaeological remains and the white travertine pool formations created by its unique geothermal setting. Because of its convenient location along a route linking the internal part of Anatolia to the Mediterranean, Hierapolis became one of the most important Hellenistic-Roman cities in Phrygia. Unfortunately, because of the high seismicity of the region, the city was almost completely destroyed and rebuilt several times during its history until a destructive earthquake in the middle of the seventh century CE, when Hierapolis went into decline. There have been some studies revealing the important vestiges of the ancient city to understand the urban layout in the various epochs of its development. Some systematic excavations and restorations have been carried out in the necropolis, the urban area, and the rural neighborhood of the ancient city for more than a half century (D’Andria and Caggia 2007; Nuzzo et al. 2009). Large-scale digital maps of the site were produced by terrestrial and satellite-based [i.e., Global Positioning System (GPS)] surveying techniques, and this topographical data comprises the fundamental spatial information for archaeological Geographic Information System (GIS) for the ancient city (Astori et al. 2003). Remote-sensing techniques have also been used to integrate the spatial data in the site map for creating an orthophoto product in the Hierapolis area to provide constant support to the management of data in archaeological GIS (Bonfanti et al. 2007; Castrianni et al. 2010). The Atlas of Hierapolis in Phrygia was prepared and published online by the Ancient Topography, Archaeology and Remote Sensing (ANTARES) Laboratory run by the Institute for Archaeological and Monumental Heritage of the Italian National Research Council (D’Andria et al. 2008). This online atlas provides views of the cartography and the historical, archaeological, and topographical data associated with it.

As previously mentioned, this is one of the most important archaeological sites in Turkey. Although the archaeological site of Hierapolis has been excavated and restored over the years, the theater of Hierapolis is well preserved, especially the stage buildings, which were beautifully decorated with reliefs (Fig. 1). The Hierapolis theater was built in the second century CE under the Roman Emperor Hadrian during a period of extensive rebuilding following a destructive earthquake in CE 60. It was later restored under Septimus Severus (CE 193–211). At this time, the scenae frons was modified and decorated with elaborate limestone and marble carvings. Although the exterior is relatively unpretentious as viewed from the front, the interior contains one of Anatolia’s most complete and best-preserved collections of Greco-Roman theater decorations (Hines 2001). There is an extensive literature on the history of the Hierapolis theater, but this is not the main focus of this study.

Even though the site has been well documented, its exact and precise geometrical shape is not yet known. There have been some studies in the literature on what geometrical form was used in the construction of a theater by the Romans. The number of quantitative analysis schemes used for the determination of the characteristic shape of a theater is, however, limited. It is known that in general theaters are semicircular in shape, but there is a need to determine the precise shape of the theater. The current study aims to search the geometrical shape of the theater of Hierapolis, believed to have been well-preserved, by using terrestrial measurements made directly on the site. A direct survey of the theater remains was made by using a total station theodolite set up over project control stations. Hence, a reliable data set was comprised of surveying points of the theater. Thus, the study addresses the issue of determining the geometric form of the Hierapolis theater by fitting a geometrical shape (i.e., an ellipse, a circle) to these measured theater data. Because theater walls are generally elliptical in shape, the well-known ellipse-fitting and circle-fitting algorithms were presented for computing the geometrical parameters.

In this study, the authors plan to survey the characteristic arcs of the theater by a total station, determine three-dimensional point...