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Study of the Structure and Plan of Sassanian Chahartaqs in Isfahan Province and Their Placement Based on Satellite Imagery

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ABSTRACT

Isfahan Province, with its favorable environmental conditions, has long been a significant habitat for human communities. Among the important and controversial archaeological sites in this region are the Sassanian-era Chahartaqs (four-arched structures) and fire temples. Investigating the settlement patterns of these Chahartaqs can significantly contribute to historical and archaeological research related to this area. The remarkable progress in archaeology has undoubtedly been achieved through the effective use of modern knowledge and interdisciplinary approaches. Technologies such as aerial and satellite imagery, as well as remote sensing, have played a crucial role in advancing this field. This study aims to examine the distance of Chahartaqs from settlements, agricultural lands, water sources, and mountain ranges, as well as their architectural elements, decorations, and construction materials. Notable Chahartaqs in the region, such as those in Niasar, Shirkooh, Natanz, Qaleh-Dar, and Khorramdasht, are analyzed in detail. Additionally, the reasons for the abundance of these structures in Isfahan Province compared to other regions during the Sassanian period are explored. The research also utilizes aerial and satellite imagery to study the positioning of these structures in relation to natural and artificial phenomena in their vicinity. By integrating traditional archaeological methods with modern technologies, this study sheds light on the spatial distribution, architectural features, and environmental context of Sassanian Chahartaqs in Isfahan Province, offering new insights into their historical and cultural significance.

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Introduction

The Sassanian Empire (224–651 CE), the last dynasty of ancient Iran, played a significant role in urbanization and development. By replacing nomadic and tribal lifestyles with a centralized urban system, they brought about a major transformation in Iran's social and political structure. With the rise of Ardashir I in the 3rd century CE, the Sassanians sought to establish a new national and religious identity under the name "Iran." This identity, rooted in Zoroastrianism as the state religion, served not only as a belief system but also as a tool for the clergy to exert influence over all aspects of public life. Consequently, the construction of Chahartaqs (four-arched structures) and fire temples across the Sassanian Empire, particularly along communication routes and population centers, had not only religious but also political, social, and economic functions. These structures acted as propaganda symbols for the Sassanian government, promoting its ideology and strengthening national unity. Isfahan, as one of the key regions during the Sassanian period, held a special position. Due to its strategic location at the crossroads of north-south and east-west trade routes, it was consistently significant for various ruling powers. Historical sources, including the remarks of Hormozan to Umar ibn al-Khattab, indicate that Isfahan was regarded as the "head" of Iran during the Sassanian era, underscoring its importance. This privileged status made Isfahan a hub for cultural, artistic, and architectural interactions (Huff, 1974; Daryaee, 2003; Mansouri & Javadi, 2019).

This study utilizes aerial and satellite imagery to examine the positioning of prominent Chahartaqs in Isfahan Province, including those in Niasar, Shirkooh, Natanz, Khorramdasht, and Qaleh-Dar. The research aims to analyze the placement of these structures in relation to environmental factors such as proximity to settlements, agricultural lands, water sources, and mountain ranges, as well as to explore their architectural features and construction materials. Additionally, the reasons for the abundance of these structures in Isfahan compared to other regions during the Sassanian period and their potential uses in the Islamic era are investigated. By integrating traditional archaeological methods with modern technologies, this study seeks to shed light on the spatial distribution, architectural characteristics, and environmental context of Sassanian Chahartaqs in Isfahan, offering new insights into their historical and cultural significance.

Methodology

This study adopts a multi-disciplinary approach, combining satellite imagery analysis, field surveys, and historical text reviews. Satellite images were used to determine the geographical distribution of Chahartaqs and assess their relationship with surrounding landscapes. Field surveys were conducted at selected sites to document architectural details, construction techniques, and material composition. Archival research, including historical manuscripts and previous archaeological reports, provided contextual information on the function and evolution of these structures. The methodology also involved comparative analysis with Chahartaqs in other regions, identifying similarities and regional adaptations. Geospatial mapping techniques were employed to visualize settlement patterns and connectivity between fire temples and major trade routes. This integrative approach ensures a comprehensive understanding of the spatial, architectural, and functional aspects of Sassanian-era Chahartaqs in Isfahan province.

Discussion

Formation and Classification of Chahartaqs

Chahartaqs are structures with diverse functions in Iranian architecture, recognized as symbols of Sassanian architecture. These buildings typically feature four pillars and a central dome and are referred to in historical and Islamic texts as Chahartaq, Chahardari, or Gombad. Chahartaqs not only served religious purposes but also symbolized the political and social power of the Sassanians. By combining Parthian heritage and Zoroastrian ideology, the Sassanians used these structures to consolidate their rule and promote their religion. Depicting fire altars on coins, constructing fire temples, and converting other temples into fire temples were key actions taken by the Sassanians. Some scholars, like Godard, classify Chahartaqs into four groups: open-air fire temples, marker Chahartaqs, fire temples, and fire altars. Mary Boyce believes that Chahartaqs originally had surrounding corridors that were later destroyed. Recent theories suggest astronomical and observatory functions

for these structures. Galdar further categorizes Chahartaqs into three types: standalone, enclosed, and composite, which include combinations such as Chahartaq with corridors, rooms, and iwans. These classifications highlight the diverse uses and significance of Chahartaqs in ancient Iranian architecture and culture (Boyce, 1975; Godard, 2009; Mirzāei, 2009).

Niasar Chahartaq

The Niasar Chahartaq, located 20 km west of Kashan, is a prominent Sassanian-era structure built by Ardashir I near the Niasar spring. Constructed on a rock, it features a cubic structure with a dome that exemplifies Sassanian architectural harmony and geometric proportions. The materials used include rubble stones, dressed stones, plaster, and sand. The dome, which had collapsed, was reconstructed in 2015. The Chahartaq has four pillars, four entrances, and a dome built without formwork, with arches gradually narrowing inward. It is similar in size to the Chahartaqs of Natanz and Khorramdasht and includes four skylights at the dome's base. The dome was reconstructed in 1955 in a non-traditional manner, inconsistent with the Sassanian architectural style (Ghirshman, 2000; Rezaienia, 2018).

Khorramdasht Chahartaq

The Khorramdasht Chahartaq is located at an altitude of 1,182 m, near Khorramdasht village on the old Kashan-Natanz road. Built on a stone platform east of the village, little is known about its research history. Construction materials include unworked local stones, rubble stones, and plaster mortar. Only the four main pillars remain, as the dome, arches, and squinches have been lost. A circular space in the center likely housed a fire altar. A 90 cm-high wall surrounds the structure, and architectural remains in the northeast suggest three rectangular halls. Recent reconstructions of the arches used incompatible materials, resulting in egg-shaped to elliptical forms. The Chahartaq is comparable in size to those in Niasar and Natanz (Naraghi, 1969; Kleiss, 1999; Mohammadifar *et al*., 2012).

Natanz Chahartaq

The Natanz Chahartaq is located west of the Jameh Mosque of Natanz, at an altitude of 1642 m, within the city's historical core. Constructed with rubble stone and gypsum mortar, the structure features four pillars, a southern arch, and remnants of a dome, while three other arches and the roof have collapsed. Restoration efforts between 2015 and 2017 included rebuilding two of the four main arches.

Ghirshman compared this Chahartaq to the Farashband fire temple, and traces of decorative elements and ancient paint layers have been observed. Its central space, similar to other Chahartaqs such as Niasar and Khorramdasht, suggests it once housed a fire altar. Additionally, its location and resemblance to other Sassanian-era fire temples reinforce its religious and historical significance (Godard, 1992; Ghirshman, 2000; Azam-Vaghefi, 2017).

Shirkooh Chahartaq

Shirkooh Chahartaq is located 36 km northwest of Naeen and 5 km west of Saparu village, at an altitude of 1825 m. Constructed with rubble stone, gypsum mortar, and clay, it features a domed structure, pillars, arches, and vaults. A 2009 restoration modified the structure, making the pillars rectangular instead of their original form. This Chahartaq shares architectural similarities with Nakhlak and Niasar, maintaining a square plan with narrowing arches toward the top. Comparative analysis of pottery fragments suggests a Sassanian-era origin. In addition to the Chahartaq, the site includes a fortress, a stone platform, and the Shirkooh cave. Natural erosion and human activity have caused damage, yet the structure remains an important historical and architectural landmark (Davoudzadeh, 1972; Shah-Hosseini, 2002; Baghsheikhi *et al*., 2020; Haji-Mohammadalian, 2007, 2008; Khosrowzadeh, 2014).

Qaleh-Dar Chahartaq

Qaleh-Dar Chahartaq is located 43 km southwest of Naeen, at an altitude of 2042 m, atop a hill overlooking Qaleh-Dar village. Built with rubble stone and gypsum mortar, the structure features two standing pillars, one collapsed pillar and a stone wall. Its approximate area is 37.69 m^2, with a maximum remaining height of 4.20 m. Siroux, in his studies on ancient routes in Isfahan province, suggested that this site might have housed a Zoroastrian sacred fire. The construction incorporates smoother stones in the squinches and larger, irregular stones in other sections. Remnants of walls on its western and southern sides suggest the presence of a

platform. Despite significant damage over time, this Chahartaq remains an important example of Sassanian architecture (Javeri, 2006; Siroux, 1978; Haji-Mohammadalian, 2011).

Architectural Characteristics of Chahartaqs

Chahartaqs typically feature a square plan with four robust pillars supporting a dome. The construction materials primarily include rubble stone and gypsum mortar, demonstrating Sassanian masonry techniques. The design emphasizes geometric precision, with symmetrical proportions contributing to structural stability. The domes, often reconstructed, reveal variations in curvature and height, indicating regional stylistic influences.

Spatial Distribution and Strategic Placement

Analysis of satellite imagery reveals that Chahartaqs in Isfahan were strategically positioned near trade routes, water sources, and elevated terrains. For instance, Niasar's Chahartaq overlooks a vital water source, while Shirkooh's location within a mountainous setting suggests a defensive function. The proximity to agricultural lands further indicates a socio-economic connection, possibly serving as centers of resource management.

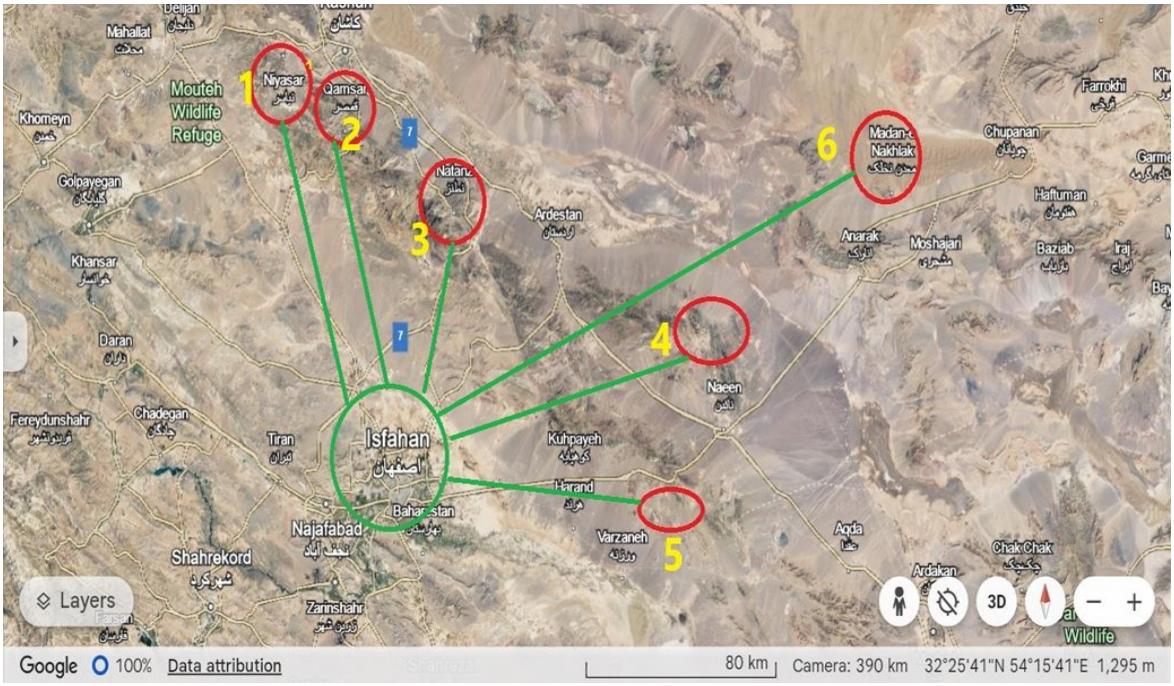

Figure 1: Location of the Chahartaqs and fire temples in Isfahan Province: 1- Niasar Chahartaq; 2- Khorramdasht Chahartaq; 3- Natanz Chahartaq; 4- Shirkooh/Saparu Chahartaq; 5- Qaleh-Dar Chahartaq; 6- Nakhlak Chahartaq (Google Earth).

Religious and Socio-Political Functions

While traditionally associated with fire worship, evidence suggests that some Chahartaqs served administrative and military roles. The alignment of these structures with major travel routes implies their function as markers or watchtowers. Additionally, their integration into urban centers supports the theory of Chahartaqs as multi-functional spaces, accommodating religious, political, and logistical needs.

Comparative Analysis with Other Regions

Comparing Isfahan's Chahartaqs with those in Fars and Kerman reveals both similarities and unique adaptations. For example, the Chahartaq of Niasar closely resembles those found in Kazerun, exhibiting similar dome construction and material composition. However, Isfahan's structures display greater variation in their strategic placement, reflecting the region's diverse topography.

Preservation Challenges and Conservation Strategies

Many Chahartaqs in Isfahan suffer from erosion, structural collapse, and human encroachment. Restoration efforts, such as those undertaken at Niasar and Natanz, highlight the challenges of preserving Sassanian architecture. Implementing advanced conservation techniques, including 3D

mapping and virtual reconstruction, can aid in documenting and safeguarding these historical sites.

Conclusion

Based on the data collected from the analysis and study of aerial and satellite images in this research, it is evident that the location of the Chahartaqs on mountain slopes and hills, near major roads, suggests that their primary function was religious. However, in some cases, these structures might have also served as commemorative monuments or milestones. Another notable feature from the aerial photos is the geometric shape and structural design of the Chahartaqs, which convey historical and architectural engineering insights. Despite their simple construction, they have withstood for centuries. The innovative techniques used in their construction, the careful selection of local materials, and the harmonious integration with the environment have contributed to their enduring nature.

The symmetry and purposeful use of numbers further enhanced the beauty and magnificence of these buildings. The choice of location was not accidental, and factors such as water accessibility, strong stone foundations, and relative distance from populated areas for tranquility and spirituality were crucial. While some buildings were built solely for religious purposes, others had multiple functions. Upon analyzing the aerial images, satellite data, and field studies, the researcher believes that these Chahartaqs were not standalone structures but included annexes that have since disappeared. Each of the five Chahartaqs in Isfahan shares a similar plan, consisting of a four-room layout with four entrances and a dome. These buildings were constructed using rubble stones and gypsum mortar. Geographically, except for the ones in Shirkooh and Nakhlak, which are aligned with the cardinal directions, the other buildings are oriented slightly off from the north. All five buildings are situated in elevated areas near a water source. Architectural style-wise, the vaults and arches suggest they were built without molds, tapering inward as they rise, eventually coming together at the apex.

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