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Analysis of the Daylighting as a Sustainable and Architectural Elements for Al-Kadhima in Shrine in Baghdad, Iraq

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Abstract

The architecture of the holy shrines of the two Imams in the Iraqi capital, Baghdad, is considered as a heritage and an important building that includes astronomical phenomena, the most important of which is the continuity of daylight. The research problem of the present study revolves around the daily and sustainable lighting in the room of the two shrines, according to the observation, which leads to the determining of the extent of that daylight in the room of the shrine. The study investigated in its route the sunlight and its direction fluctuation during the days of the year to create a sustainable lighting environment. The present study aims at detecting this phenomenon and proving it in a practical way. The present study adopts an experimental and analytical method, represented in collecting geometrical and architectural data and then establishing a theoretical basis for analyzing the related framework. The practical part of the study provides a comprehensive survey of the six windows located at the base of the two domes, showing the extent of the penetration of sunlight into the room of the holy shrine and illuminating it properly. The study found that the daylight direction along the years was fitted with the openings along the shrine to cover all the zones from the Summer Solstice to the Winter Solstice.

Keywords: Shrine, Azimuth angle, daylight, Photosynthetic, sustainability.

Introduction

The need to study the penetration of sunlight through the windows of the base of the two domes of the architecture of the shrine to benefit from such an environmental design that touches on the traditional, social, ideological, and religious environment within the architecture of the shrine. The design of a sustainable light environment serves the above situation in the architecture of the shrine (1,p32). The present study aims to determine the extent of benefiting from sunlight during the day and creating a sustainable light environment. To obtain the objectives of the present study, the study adopts an Experimental-analytical method as follows: Theoretically, data are collected and a theoretical basis for a theoretical framework is established. Practically, sustainable daylight creates a sustainable environmental condition by penetrating sunlight through the windows overlooking the room of the shrine. The amount of light penetrating the room creates a sustainable light environment to serve the functionality of the shrine's architecture from a doctrinal and societal standpoint.

Sustainability in Traditional Architecture and its Cosmic Influence

The ancient buildings have been and still are a researchable model. The first pioneering architects adopted daylight as the only and basic means to benefit from it in daytime activities concerning religious and other aspects. Based on this principle, there is a permanent relationship between the design of buildings and sunlight, especially in the Middle East region in addition to the symbolic advantage that sunlight has had in philosophy and religion over centuries in relation to the type of needs based on its exploitation (2, p59). In every era, there is an advantage in the development of its exploitation with its own era techniques. Local architecture is rich in such amazing techniques (3, p44). The first engineers were ahead of their time and exploited natural resources in constructing buildings and introducing sunlight as a sustainable environmental element, which is the key to efficient energy use and raising the level of the building in its natural performance that is consistent with the requirements of the individual and society (4,p92). The cultures of the ancient Maya and Inca peoples used sunlight in architecture for multiple purposes, including worship and honoring the gods in their architectural works for lighting or for symbolic or apparent purposes through the effect that light generates through its transmission in architectural elements, which indicates their understanding of the apparent movement of the sun and their ability to create a calendar for urgent needs, such as agriculture (5,p81). In addition, the Maya and Inca peoples knew how to optimally exploit sunlight and create axes in ritual buildings that were directed to celestial events and fell within the angle of solar movement. They benefited from this for agricultural purposes (6, p17).

As for the ancient Indian peoples, it is found that temples were built according to the principle of the mandala, in addition to astronomical alignments and the relationship of the sun and the moon in providing religious functions, as in the Hindu temple of Angkorwat in Cambodia. It is noticed that it is directed towards the basic points that have a continuous relationship with the sun (7, p110).

Ranasi and its spiritual tradition, like Kashi Khanda, give the myths, stories, and rituals associated with each of the earlier sun temples and reveal the importance of the sun to the residents and pilgrims. The sun is understood to be a god of care and protection, providing relief from the problems of ordinary life, such as skin diseases, infertility, hunger, aging, and death. Kashi Khanda also includes references to possible observations of sunspots, meteor showers, and a total solar eclipse in 1054 AD (8, p92).

Rock structures:

The ancient and mysterious giant rock structures, spreading in many places and having architectural features, were built from rocks with a regular geometric shape, weighing tens and hundreds of tons (9, p64). These structures are often called the Cyclopian, such as the English Stonehenge, the Lebanese Baalbek, and the Egyptian pyramids. They may also be in the form of stones without links that date back to prehistoric times and are related to the calendar. They observe the sun, solstices, and equinoxes, forming places of worship for the twelve zodiac gods and the sun. (10, p21).

Pantheon Rome Temple

The Pantheon Temple is known as an ancient Roman pagan temple. It symbolizes the sun. It has symbolic interpretations, including the eye of the sky due to the presence of the 9 m hole in the middle of the dome. It is considered to be the god of the sky, as it was called in the ancient pagan Turanian civilization. It has spread in Europe and eastern North Central Asia (11, p76). This is confirmed by the ancient tent houses, still present in Central Asia as conclusive evidence that this religion was the foundation of this type of architecture. It was also used in the Ottoman Empire later, with an opening in the middle of the dome covered from the inside with blue tiles (12, p84). The difference is that the dome of Karatay Madrasa has another symbolism in terms of the Islamic religion. In addition, it has enhanced the efficiency of environmental performance through daylight (13, p211).

(a) Dome of Karatay Medrese with an opening (ULU GÖZ) at the center with a cross across it. The main opening is surrounded by other "sun" diagrams on a turquoise-blue background.

(b) A view from inside of the pagan temple Pantheon.

Fig. 1: The opening of the sunlight entrance to the Pantheon Temple in Greece and the Karatay Medrese opening in Turkey

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Moreover, the Greek and Roman civilizations emphasized the movement of the sun in their temples because of its important role in their temples and architecture (14, p66).

Church Architecture

The higher authorities directed churches, especially those heading to South America, to have their buildings designed with liturgical architecture in the third century AD, for spiritual considerations in the process of introducing sunlight into churches on the days of the equinoxes or solstices and creating symbolic and philosophical values that are astronomically and culturally linked. The architecture of the Middle Ages and the building of churches at that time did not separate the division of time from the division of space (15, p83). The measurement of time depended on the movement of celestial bodies, which could not be calculated except by observing their fixed path. Therefore, the orientation of the churches and the subsequent optimal use of light inside the church wasfor spiritual considerations (16, p18). As an example, it was revealed in Too ambiguous. Refer to the article or remove this expression please. that 18 churches out of 22 in Mexico are oriented towards the vernal or autumn equinox. In addition, 60 lighting sites were identified that were used for agricultural purposes by Native Americans in the western United States and South America (17, p176).

Methodology

Architecture of Shrine Body

The location of the shrine relative to the main direction lines is shown in the following figure. It is evident that the building boundaries are parallel to the north, south, east, and west directions. The main space of the shrine contains two domes at the top and six windows below them. There is a window on the north side, another on the south side, and two windows on both the east and west sides. The base of each window is approximately 10 meters above the floor of the courtyard, and the height of each window is 210 cm. There are also lamps to illuminate the place during times when the sun is obscured by clouds and dust storms.

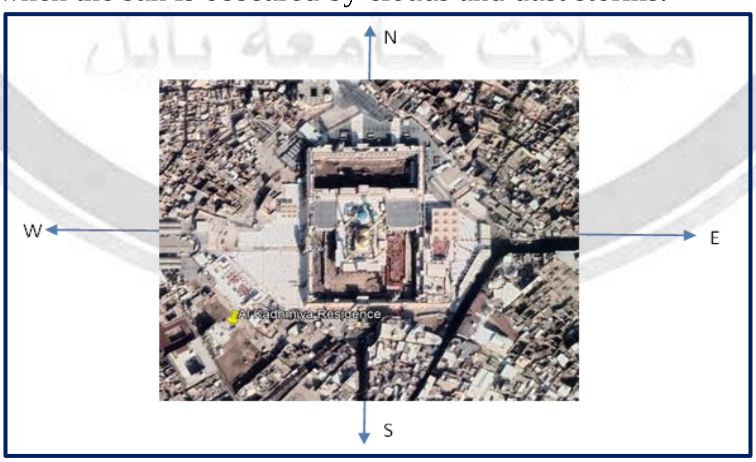

Fig. 2: The opening of the sunlight entrance to the Pantheon Temple in Greece and the Karatay Medrese opening in Turkey

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Calculating Azimuth Angles

The azimuth angles, which represent the movement of the sun during daylight hours around the Holy Shrine, were calculated according to the astronomical equations for the movement of the Earth, the angle of inclination of the Earth, and the latitude of Al-Kadhimain Shrine. The times of the solstice of the year were chosen as indicators to study the movement of the sun around the building to determine the effectiveness of the six windows designed around the central courtyard of the shrine. The times that were chosen are four times, represented by the twenty-first day of the months (March, June, September, and December). The following equations were used for applying the astronomical analysis (18, p45) (19, p72) (20, p97):

$$\sin \delta = 0.39795 \cdot \cos [\, 0.98563 \cdot (N - 173\,)] \qquad (1)$$

$$\alpha = \sin^{-1}(\sin \delta \;\; \sin \emptyset + \cos \delta \;\; \cos \omega \;\; \cos \emptyset) \qquad (2)$$

$$\omega = 15\,(to - 12) \qquad (3)$$

$$A = \;\cos^{-1}\left(\frac{\sin \delta \;\; \sin \emptyset - \cos \delta \;\; \cos \omega \;\; \cos \emptyset}{\cos \alpha}\right) \qquad (4)$$

where: α: sun rays angle, δ: angle of Sun declination, N: number of days in the year, ∅= latitude of a destination location, To: hours counted from midnight, ω: hour angle, A: Azimuth angle.

Calculating Solar Radiation Angles

The angles facing the window during daylight hours were calculated using equations (Eq. 1 and Eq. 2) for the four selected times (the times of the solstices and equinoxes) to determine the extent of the solar rays and the maximum possible point they could reach on the opposite walls of the holy shrine. The solar rays were calculated starting from the angle after sunrise and the entry of the sun's rays into the holy shrine, and up to the highest angle representing the highest position of the sun at noon.

Results and Discussion

Specifically, predicting the amount of solar radiation is of utmost importance in many engineering applications. Furthermore, solar radiation estimates are important in energy studies for buildings. Calculating solar radiation and shading involves many equations and many influencing factors that must be taken into account. The user only has to set some values (such as location, time, etc.) and can choose between calculations for either a specific time of the day or a whole day. The results of the rotation of the sun around the shrine, located on the meridian line, are illustrated shows in Fig. 3.

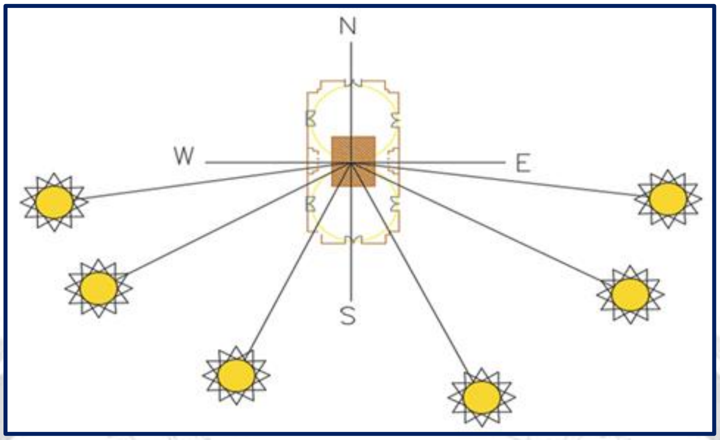

Fig. 3: The angles of rotation of the sun during the daylight hours around the Shrine for the equinoxes (3/21 and 9/21).

According to the equinoxes (March 21st and September 21st), Observations reveal that the sun's rotation around the domes aligns with both the vernal equinox and the second equinox of the ninth month..

Fig. 4 shows the sun continues its rotation from the vernal equinox until the summer solstice on the date (6/21). This reinforces what has been reached, whether by field observation or by scientific, mathematical, or astronomical study.

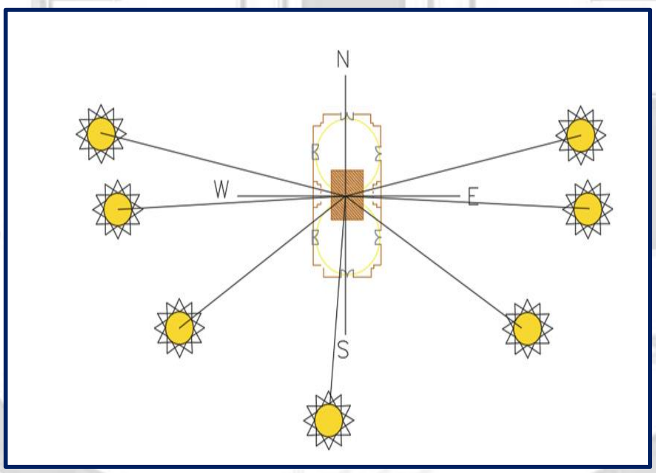

Fig. 4: Angles of rotation of the sun during daylight hours around the Shrine according to the summer solstice (6/21).

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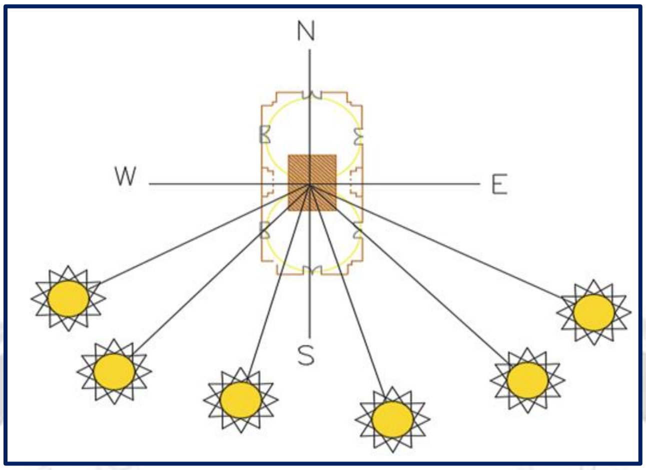

Fig. 5: Angles of rotation of the sun during daylight hours around the Shrine according to the winter solstice (12/21).

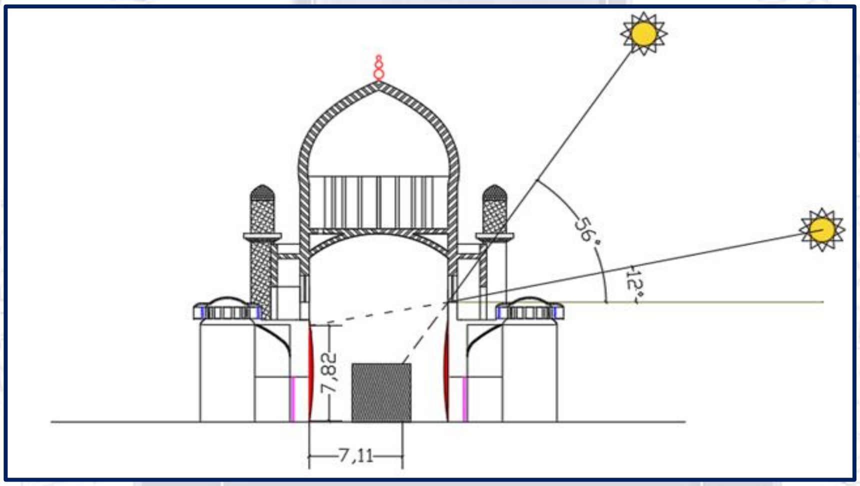

Fig. 6: The angle of solar radiation at the beginning of the morning and noon hours towards the Shrine according to the two solstices (3/21 and 9/21).

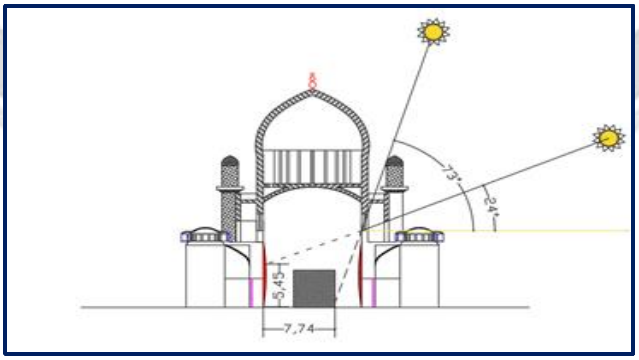

Fig. 7: The angle of solar radiation at the beginning of the morning and noon hours towards the Shrine according to the summer solstice 6/21.

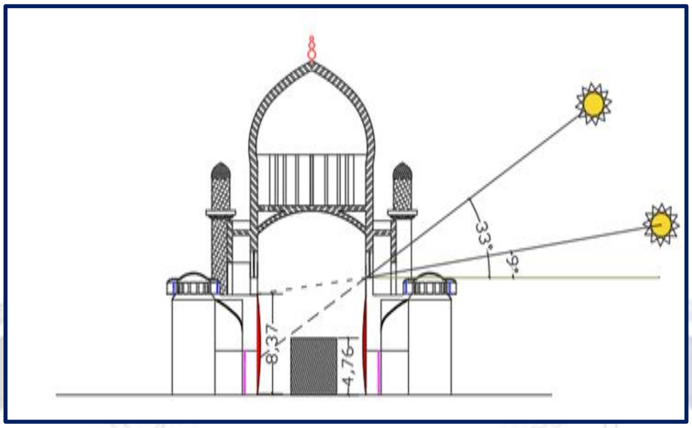

Fig. 8: The angle of solar radiation at the beginning of the morning and noon hours towards the Shrine according to the winter solstice (12/21).

In this figure, the time of the sun's rays and its sustained light inside the holy shrine are less than that less than it is during the rest of the days of the year. Soon later, it returns again to the vernal equinox, so that its light, luminosity, and sustainability continue and give the holy place a permanent light and environmental sustainability.

Fig. 9: The field observation of the illumination of the place with sunlight daily (lensed by the photography team in Al-Kadhimain Building.

Conclusions

After the entry of the sun was calculated in an astronomical mathematical manner and through astronomical mathematical calculations, it was practically concluded that the architecture of Al-Kadhimain is environmental and sustainable architecture throughout the year. This was also done through daily follow-up and understanding of the subject of sunrise and sunset in the architecture of the shrine. It is something carefully calculated because it has a significant impact on creating a sustainable lighting environment that is appropriate to the spiritual and social situation and its influential social scope, which is considered one of the most

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prominent techniques at a time when the architect was able to employ his capabilities and expertise in a sacred place that has a great impact on space and time. The conclusions can be as follows:

1. In Fig. 3, according to the two equinoxes (3/21 and 9/21), it is clear that the rotation of the sun around the domes at the spring equinox, as well as at the second equinox, September, is completely clear.

2. In Fig. 4, according to the summer solstice (6/21). The sun continues rotating from the vernal equinox until the summer solstice on the date (6/21), which reinforces what has been reached, whether by field navigation or by scientific, mathematical, or astronomical study.

3. In Fig. 5, according to the winter solstice (12/21), the sun continues revolving around the domes, but far away from them, but the sun's ray enters within the angle of its entry into the holy shrine and forms a luminous continuity.

4. In Fig. 6, according to the two solstices (3/21 and 9/21), sunlight moves on the glazed walls and the holy shrine, which helps in the reflection of sunlight in a dazzling manner and a halo of light that casts its shadow on the visitor's spirituality automatically. It cannot be calculated.

5. In Fig. 7, according to the summer solstice on (6/21), there is an increase in the angle of entry of the sun's rays, which gives more of the halo surrounding the place and more time during the day, which remains until six thirty in the evening.

6. In Fig. 8, according to the winter solstice (12/21). The time of the sun's rays and its sustained light inside the holy shrine are less than that during the rest of the days of the year, which soon later returns again to the vernal equinox so that its light, luminosity, and sustainability continue and give the holy place a permanent light and environmental sustainability.

7. The optical sustainability is related to the functional and social situation that was defined by the religious visits that characterized this sacred architecture. The room of the shrine contains electric lamps to illuminate the place during times when sunlight is blocked, such as during dust storms and cloudy winter days as in Fig. 9.

Recommendations

The present study recommends that the architecture of Al-Kadhimain Shrine is environmentally sustainable architecture and must be preserved as follows:

1. Paying full attention to the windows of the domes that let sunlight through their way into the holy shrine, and paying attention to the cleanliness of the windows surrounding the domes.

2. Paying full attention to the glazed walls of the shrine from the inside, taking care of them, and maintaining them because of the importance of these glazed walls in reflecting and spreading sunlight, which forms a halo of light inside the holy shrine.

3. Giving priority to sunlight during the day has a great impact in enriching the place with the aura of natural light which constitutes a spiritual effect that is commensurate with the holiness of the place.

4. Directing architecture students to such astronomical situations to study and examine them.
5. Guiding architecture students to find similar formulas in optical sustainability.

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تحليل ضوء النهار كعنصر مستدام ومعماري لمرقد الكاظمة في بغداد، العراق

محمود رزوقي جنجون & وسام جابر شمخي & رواء عبد مناف الشلاه & ندى مبارك

قسم الهندسة المعمارية، كلية الهندسة، جامعة بابل، الحلة، العراق

الملخص

تعتبر عمارة مرقدي الامامين الشريفين في العاصمة العراقية بغداد من الابنية التراثية المهمة، تتضمن ظواهر فلكية اهمها استمرارية ضوء النهار. تتمحور مشكلة البحث في الدراسة الحالية حول الإضاءة اليومية المستدامة في حجرة المرقدين الذي يؤدي إلى تحديد مدى ضوء النهار في حجرة المرقد. وقد اكد مسار الدراسة ان ضوء الشمس وتقلب اتجاهه خلال أيام السنة ادى الى خلق بيئة ذات إضاءة مستدامة، وتهدف الدراسة الحالية إلى الكشف عن هذه الظاهرة وإثباتها عملياً، تعتمد الدراسة الحالية المنهج التجريبي التحليلي، المتمثل في جمع البيانات الهندسية والمعمارية ومن ثم وضع أساس نظري لتحليل الإطار المتعلق بها. ويقدم الجزء العملي من الدراسة مسحاً شاملاً للنوافذ الستة الموجودة في قاعدة القبتين، يبين مدى تغلغل ضوء الشمس إلى داخل حجرة المرقد الشريف وإضاءتها بالشكل المناسب. ووجدت الدراسة أن اتجاه ضوء النهار على مر السنين تم تجهيزه بالفتحات الموجودة على طول الضريح لتغطية جميع المناطق من الانقلاب الصيفي إلى الانقلاب الشتوي .

الكلمات الدالة: الضريح، زاوية السمت، ضوء النهار، التمثيل الضوئي، الاستدامة.