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Aslanhane (Ahi Şerafettin) Mosque Energy Efficiency Analysis

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Abstract

Throughout history, humanity has undergone numerous changes and developments. These have aimed to improve people's comfort in areas such as living, shopping, education, and worship. Each development has brought about new needs, which have required sustainable solutions. The Industrial Revolution, one of the most significant changes in our history, sparked discussions about energy and its sustainability. Although energy has always been a crucial human need, the Industrial Revolution brought about concerns regarding environmental sustainability. The term 'environmental sustainability was first introduced in the 1980s, but examples of its application can be traced back throughout history. The Aslanhane Mosque in Ankara, also known as Ahi Şerafettin Mosque, is one such example. Built in the 13th century, it boasts impressive energy efficiency and management for its time. This paper aims to identify the architectural and energetic features of the Aslanhane (Ahi Şerafettin) mosque using in-depth interviews and systematic literature analysis methods and also discuss what can be done to integrate contemporary technologies.

Keywords: Aslanhane Mosque, Energy Efficiency, Energy Management, Historic Places

Aslanhane (Ahi Şerafettin) Camii Enerji Verimliliği Analizi

Özet

İnsanoğlu tarih boyunca birçok değişim ve gelişmeye şahit olmuştur. Bu gelişmeler insanların birçok alanda konforunu artırmak için ortaya çıkmıştır. Her gelişme ile birlikte yeni ihtiyaçlar da ortaya çıkmış ve bu döngüyü sürdürme durumu oluşmuştur. Günümüzü etkileyen en önemli değişimlerden biri olan sanayi devrimi ile birlikte enerji ve sürdürülebilirlik kavramı tartışılmaya başlanmıştır. Enerji her zaman insanların en önemli ihtiyacı olmasına rağmen yaşanan bu devrimle birlikte yaşanılan çevrenin devamlılığı konusunda kaygılar oluşmaya başlamıştır. Çevresel sürdürülebilirlik kavramı literatüre 1980'lerde girmiştir. Ancak kavramın daha öncelerde uygulandığı örnekler tarih boyunca görülmektedir. Ankara Aslanhane (Ahi Şerafettin) camii de bunlardan biridir ve 13. yüzyılda inşa edilmiştir. Enerji verimliliği ve yönetimi açısından yapıldığı döneme ilişkin çevresel sürdürülebilirliğe ait önemli özelliklere sahiptir. Bu makale, Aslanhane (Ahi Şerafettin) camisinin mimari ve enerjiye dair özelliklerini derinlemesine görüşme ve sistematik literatür analizi yöntemleri kullanılarak camiye çağdaş teknolojileri entegre etmek için neler yapılabileceğini tartışmayı amaçlamaktadır.

Anahtar Kelimeler: Aslanhane Camii, Enerji Verimliliği, Enerji Yönetimi, Tarihi Yerler

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Introduction

Energy has been a fundamental necessity of humanity throughout history, manifested in various forms across different eras. The construction sector has consistently demanded the greatest quantity of energy, and the value of energy and raw materials has risen significantly, particularly following the advent of the Industrial Revolution. The Industrial Revolution, which began in the 18th century, had a profound impact on human life by marking the beginning of the widespread use of energy, which was previously derived solely from human labor. (Orchard, 1935) highlights the crucial requirement of energy during this period. Before the Industrial Revolution, artificial energy sources were primarily used for heating and lighting. While crucial for meeting human energy needs, the Industrial Revolution raised concerns about the sustainability of transportation and energy sources. However, an analysis of historical buildings reveals that there is, in fact, an effective use of energy and a sustainability of energy.

The concept of sustainability was initially introduced to the literature in the 1980s (United Nation, 1987). However, examples of its application can be found throughout the history of construction. The construction sector is the largest consumer of energy, accounting for 30% of global energy consumption (Santamouris & Vasilakopoulou, 2021). Addressing this issue is crucial for achieving sustainable development goals, as economic and ecological sustainability are key priorities that must be balanced with social sustainability.

In the past two decades, the construction sector has seen a rise in environmental sustainability, green concepts, and ecological certificates. Companies are striving to create eco-friendly buildings. As (Cooley, 2014) stated, “The greenest building is the one that's already built”. However, it is important to note that vernacular architectures also incorporate passive energy management systems in their buildings and have green certificates. Vernacular architecture can be used to develop sustainable or green buildings. Local architectural techniques vary depending on the region, but traditional materials, climatic conditions, and topography are crucial elements. Passive energy management systems are employed to ensure building sustainability and longevity. The use of traditional or vernacular construction techniques is widespread across the world. It aims to construct new, affordable, and habitable buildings. However, the most significant challenge is the availability of materials, which are necessary to apply these techniques. Additionally, highlights another important aspect of vernacular architecture (Glassie, 2000); “*Buildings, like poems, and rituals, realize culture. Their designers rationalize their actions differently. Some say they design and build as they do because it is the ancient way of their people and place. Others claim that their practice correctly manifests the universally valid laws of science. But all of them create out of the smallness of their own experience.”*

The centuries-old protected buildings are environmentally friendly, resource-efficient, and energy-saving. It is crucial to maintain socio-cultural diversity and productivity in these areas. Every design decision for sustainable architecture in these areas should consider its environmental and cultural impacts, at the local, regional, and global levels. In order to make a proper evaluation, a set of criteria is necessary.

The aim of this study is to determine whether new and original sustainable architectural design criteria are met in protected buildings by conducting in-depth interviews through focus group methodology specific to the selected field of study. The chosen location for this work is the Aslanhane Mosque, also known as Ahi Şerafettin

Mosque. Constructed in the 13th century (Eyice, 1988), it boasts significant features for its time in terms of energy efficiency and management. The mosque exhibits unique characteristics in both architecture and civil, energy, and environmental engineering fields.

Research Question and Objectives

In contrast to the past, contemporary construction projects are designed with the explicit intention of incorporating sustainability and energy efficiency considerations. This shift in approach reflects a growing awareness of the importance of these issues in the built environment. Lots of factors can be measured or simulated from the design phase. However, in the past, architects have designed these factors for utilitarian purposes only without using the terms drivability or energy efficiency. From this point of view, the utilitarian architectural practices of the past should be examined according to today's architectural and construction standards and analyzed by taking into account modern techniques.

The interrogation of the following questions is central to the elucidation of the subject matter within this article, as they serve as fundamental guiding principles for the subsequent discourse. Consequently, the objective here is directed towards obtaining comprehensive answers to these central questions, thereby enriching the scholarly discourse and advancing understanding within the field. First of all, some questions should answer. a) What dimensions and indicators can be used to measure energy efficiency in historical buildings based on literature? b) What dimensions and indicators can be used to measure energy efficiency in historical buildings based on in-deep interviews? c) What items that was used to constructing energy efficient vernacular architecture? d) Are the materials and techniques used in the 13th century still suitable for today's standards? What are the suggestions for improvement?

This paper provides a comprehensive examination of sustainability attributes within the context of contemporary challenges and architectural paradigms. The evaluation of these attributes is done through a critical lens, taking into account prevailing societal and environmental concerns. Additionally, the paper explores the Aslanhane (Ahi Şerafettin) Mosque in detail, highlighting potential strategies for the incorporation of modern technologies to address its exigencies. This analysis aims to enhance the sustainable performance of architectural structures, contributing to the discourse on responsible urban development and environmental stewardship. It synthesizes theoretical discourse and practical application to elucidate pathways for achieving this goal.

Methodology

In order to ascertain the answers to the research questions and research objectives, this study employs two distinct methodologies to determine the energy efficiency indicators of historic buildings. The first step, in-depth interviews were conducted with academicians working in this field. Experts have conducted studies on this topic and made significant contributions to this paper. In the second step involves conducting a systematic literature review using relevant keywords. This supplementary method includes reviewing highly qualified indexed journals and books. The aim of this article is to present qualitative works, rather than just theoretical studies.

The literature review was guided by the use of energy management strategies or techniques, particularly in historical prayer halls. The Web of Science, Scopus and EBSCOhost research databases are searched to include studies that do not repeat similar information and to include new studies for systematic analysis. To gain a full

understanding of the project's necessity and innovation, articles published between 2007 and 2022 were examined. There are 644 studies about Aslanhane Mosque. However, only 615 of these articles focus on energy efficiency in historic places, and 48 articles specifically address energy management in prayer halls. These articles review the architectural frameworks of historic places of worship, such as design approaches, building elements and materials used, and identify these gaps in the literature. The literature is divided into two sections: one focused solely on restoration, and the other solely on analyzing the building's energy management (Figure 1). This paper analyses the literature and investigates from an architectural perspective, combining quantitative results such as energy consumption of heating, lighting, and ventilating methods with early studies. Many quantitative factors were detected during the literature analysis phase, however, one of the most important influences for research is climatic features. Three studies were identified as being compatible with the Aslanhane Mosque in terms of climate, purpose of use and scale. Based on the common aspects of these studies, the contribution of the structural and architectural features of Aslanhane Mosque to energy efficiency has been analysed. These articles were also reviewed and included in the literature review section.

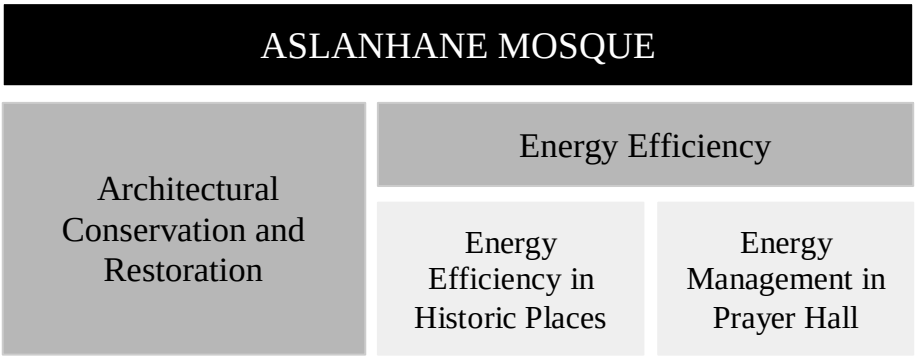

Figure 1. Literatüre review method steps

Deep Interview

The purpose of the in-depth interview was to gather expert opinions on the relevant issues. Information regarding the building's issues was obtained from experts who had personally experienced the building. Their recommendations are highlighted in this article. This paper benefited greatly from the studies conducted by experts, who possess direct insight into the Aslanhane (Ahi Şerafettin) Mosque. Experts provided information about the mosque's heating, lighting and ventilation problems. During the in-depth interview phase, questions were answered about observations and experiences during the visit. The questions prepared before the interviews are given in Table 1. These questions contributed to the experts to explain the structure according to their own fields and to identify the deficiencies in the structure. As indicated in Table 2, two architects, one city planner and one restoration specialist with at least eight years of experience were interviewed. The experts were employed by the "T.R. Ministry of Culture and Tourism, General Directorate of Cultural Heritage and Museums, General Directorate of Foundations and Ankara Cultural Heritage Preservation Regional Board Directorate." An expert was consulted for an interview. Six meetings were held with the experts to discuss the research objectives in detail and develop a sampling strategy. After conducting the interviews and analyzing the literature and experimental findings, this article was prepared.

Table 1. Interview questions

Questions about the contemporary changes made in Arslanhane Mosque
1. "Can you describe the contemporary architectural changes that have been made to the Aslanhane Mosque?"
2. "What were the main motivations or reasons for these architectural changes in the mosque?"
3. "How have these contemporary changes affected the overall aesthetic and spatial experience of the mosque?"
4. "Could you discuss any challenges or considerations that arose during the implementation of these architectural changes?"
5. "How do you think these architectural changes contribute to the modernisation or adaptation of the mosque to contemporary needs?"
6. "Are there any symbolic or cultural elements incorporated into the contemporary architectural changes to reflect the heritage or identity of the mosque?"
7. "How do these architectural changes conform to or deviate from the traditional principles of mosque architecture?"
8. "Looking to the future, what further architectural developments or improvements are being considered for the Aslanhane Mosque?"

Table 2. Experts' professional knowledge and experience

	Institution	**Profession**	**Experience Period**
Expert 1	T.C. Kültür ve Turizm Bakanlığı, Kültür Varlıkları ve Müzeler Genel Müdürlüğü	Architect	13
Expert 2	T.C. Kültür ve Turizm Bakanlığı, Kültür Varlıkları ve Müzeler Genel Müdürlüğü	Urban Planner	8
Expert 3	TC. Kültür ve Turizm Bakanlığı, Vakıflar Genel Müdürlüğü	Architect	12
Expert 4	Ankara Kültür Varlıklarını Koruma Bölge Kurulu Müdürlüğü	Restorator	10

Literature Review

After examining the relevant literature, it was decided to examine the articles under two separate headings. The first heading will cover the architectural features of Aslanhane Mosque and any studies related to its energy efficiency or sustainability. The second heading will focus on the application of energy management systems in historic places and the technological advancements that have been made in this area.

The first question pertains to the Aslanhane Mosque and its features, which have been the subject of 519 articles. In the field of architecture, several studies have been conducted on the history and physical features of the mosque (Akşit, 2018; Laikgil, 2015; Karaseki, 2007). However, the focus of this paper is on the energy management of the Aslanhane Mosque. In this regard, (Kitapci & Çelik Başok, 2021) have analysed the acoustic characteristics of the mosque. The literature review on historic places focuses on the relationship between acoustic and interior materials. The results indicate that wooden materials generally absorb sound and decrease frequency, while low ceiling height has a negative impact. Although the speech intelligibility rating was 'good', the sound energy is not homogeneous due to wooden load-bearing columns that obscure voice spread.

(Kandemir-Yucel et al., 2007) mention the effect of wooden structures on buildings. The researchers conducted a study using infrared thermography (IRT) and ultrasonic velocity measurements (UVM) to analyze a mosque. They used in situ methodology and took IR images which showed that there is a dampness problem in the timber column, ceiling, and lintels. Although the masonry stone wall has timber parts such as doors and windows, energy leakage and dampness affect these parts of the wall.

Continuing the literature review, studies on energy management in historical places reveal that energy management is generally grouped into heating, lighting, and ventilation (Makrodimitri et al., 2012). This study aims to answer three questions: 1) What does a sustainable building envelope mean for the historic environment? 2) What are the consequences of draught-proofing a historic structure? 3) What is the best approach to promoting sustainability in historic buildings: altering the building fabric or improving the building services? This question highlights the significant impact that building services have on large hall structures. Additionally, it is important to note that most historic buildings are constructed with local materials, resulting in a low degree of embodied energy and carbon. In church buildings, heating and lighting are the primary sources of carbon emissions. (Tokarčík & Rovňák, 2017) state that the main challenges in the conservation of building structures are related to energy management systems and consumption. They suggest focusing on thermal bridges and insulation. According to (Bolorforoush, 2014), the aim is to search for an energy reduction hierarchy to investigate effective ways for cathedrals in the UK. Heating is the most significant factor in energy consumption and carbon emissions. The solution is to focus on the heat at floor level. Underfloor heating systems are suitable for use in this context. The research also includes examples of energy production and renewable energy sources. (Balaji et al., 2018) mention the importance of user-driven energy efficiency in historic places and define targets and energy demand potentials. They suggest that if an energy refurbishing process is required, CEN standards can be applied or followed. (López & Frontini, 2014) express interest in solar energy production. The text suggests analysing a building, identifying suitable renewable energy sources, and developing a management plan.

The literature review draws parallels to Ankara's climate. (Sugár et al., 2020) explored the challenges faced during the retrofitting of historical buildings, including energy conservation, heritage preservation, and cost-effectiveness. The study focused on residential buildings constructed in various periods in Hungary, particularly in Budapest, and analysed them based on their architectural styles. This country has a continental climate, and the most crucial factor for energy saving is the envelope problem. (Semenyuk et al., 2018) mention the principles of energy efficiency in a continental climate, including energy conservation, interaction with the sun, renovation and re-use, social orientation, and ecological orientation.

Analysis of Aslanhane (Ahi Şerafettin) Mosque

Aslanhane (Ahi Şerafettin) Mosque; is located on sloping land in the Aslanhane Neighborhood in the Altındağ district of Ankara. It is a simple mosque that does not attract much attention with its rubble stone walls and lead-coated roof. The structure, which is one of the oldest and most important buildings in the city, is located at the southern end of Ankara Castle (see Figure 3).

The building was constructed in harmony with its topography (see Figure 2) using traditional materials and vernacular construction techniques and elements. Aslanhane Mosque set an example for timber construction mosques and masjids in Anatolia.

Especially Aslanhane mosque was inspired by a flat roof and timber load-bearing column system in Ankara's 14-15th centuries. This mosque has lots of unique elements. For example, entrances, minbar, mihrab wall, etc. The mosque has 24 wooden columns and a nearly rectangular plan (TR Governorship of Ankara, 2016). It has external dimensions of 27.5x24.7 m. It was built for charity purposes by Ahi Hüsameddin and his brother Ahi Hasaneddin, one of the notables of Ankara Ahiler. Due to the writing style of the inscription on the west door, it was first built in XIII. It is accepted that it was the beginning of the century, and it was renewed in 1289-90 AD., which is included in the minbar wall. Aslanhane (Ahi Şerafettin) Mosque contains lot of unique architectural element for centuries. All of these could conserve gradely and has been transferred to the present day. One of these elements is columns. The mosque was constructed with hypostyle, so the columns have important characteristic for this building. The 24 wooden columns are made of walnut wood and the capitals of each of these legs are made of spoiler marble Roman-Byzantine materials. These capitals are Doric and Corinthian capitals made with marble carving technique. The six wooden columns, separating them into five vertical naves and forming four rows each, are crowned with spoiled marble capitals from different Roman periods (Karaseki, 2007). These columns are carried of roof which is known that it was in the form of a flat earthen roof when it was first built. However, it was later built with a sloping hipped roof and covered with copper. The ceiling is in harmony with the roof and column style. It is worked with transverse beams that fill between the vertical beams and consoles that provide the transition to these beams. Palmette-shaped ornaments are seen in the transition with consoles and beams. The console row in the nave, which is wider and higher than the sides, has three rows (Karaseki, 2007).

The facade design is also crucial for this mosque, since entrances and other openings provide energy data. The north façade or entrance has white marble crown door, which is located in the north next to the minaret and opens to the women's quarter in the form of a balcony due to the slope of the land, is the more ornate one. This door is decorated with simple moldings, colonnades, and square prism columnar capitals on the inner side surfaces. Also, there are two windows and one entrance gate in this façade. A minaret was also constructed here. Other is west façade or entrance which stays in a sloppy area, so a balcony was constructed, and create two shops for cover the expenses of the mosque. There are nine windows and one entrance door. The entrance gate had an ornamented style and was built using tiles and bricks that is available in the 13th c. The last entrance façade is east. It is located at a low elevation compared to the road. On the east façade, there are nine windows and one entrance door. The doors are brickwork together with tiles (İşçen, 2019).

It has also unique decoration elements mihrab wall and minbar. There is the most original tile mosaic sample of the Anatolian era mihrabs (Erdoğan et al., 2007). The mihrab is shifted to the east from the axis of the mosque. The first Anatolian example, in which mosaic craftsmanship and plaster relief decoration were evaluated together, draws attention. Plaster reliefs in Iran, XII. century and XIII. It bears the characteristics of the plaster workmanship of the Great Seljuk period at the beginning of the century. The minbar was made of walnut wood minbar is decorated with special geometric motifs. It is one of the special minbars in Anatolia. The minbar door is sliced. Door wings are not available. Door arch corners are decorated with intricately carved rumi, palmette, and arabesques. The side mirrors are filled with Rumi-decorated reliefs in the geometric mesh

that creates polygonal, star, and lozenge shapes (Karaseki, 2007; TR Governorship of Ankara, 2016).

Energy Efficiency

Aslanhane Mosque is a mosque located in the Altındağ municipality of Ankara. The climate in which it is located is generally continental climate and the area where it is settled is located in a high area in Ankara (Figure 2). It was built on sloping land in harmony with the topography. The prevailing wind direction of its location is northeast. In light of this information, the energy management or energy efficiency characteristics of this mosque can be examined under four topics; lighting, heating, air conditioning, local material.

It was decided that energy analysis could be carried out according to two important methods derived from in-depth interviews and literature analysis. Evaluation of the building in today's comfort by experiencing the building or from people who have experienced it. Making approximate results according to TS 825 standards. It is known that the walls of the building were made using the masonry stone technique. Accordingly, the following calculations can be made.

The following equations, as outlined in TS 825 Thermal insulation requirements for buildings standards, are used to calculate the total heat transfer coefficient, thermal resistance, surface resistance, calculated surface thermal conduction (convection) resistance values, overall heat transfer coefficient, heat flow rate, and annual heating energy needs. The findings, based on these calculations, are presented below and discussed in the subsequent sections. The amount of the heat transferred of layers of the envelop depend on two important factor which are conductivity of the material and thickness of layer.

a) Thermal conductivity measured as the heat flow density(W/m2). Thermal conductance shown with Λ and measurement: $\Lambda = \frac{\lambda}{d(L)}$ W/m^{2}K.

b) Thermal resistance: $R = \frac{1}{\Lambda} = \frac{d}{\lambda}$

c) Thermal resistance multilayer: $R_{t=} R_1+R_2+R_3+\ldots$

d) The surface resistance emerges with two invisible layer that contribute to its total R- value. There is an inside surface resistance and an outside surface resistance. It shows that;

$R_{t=} R_{si}+R_2+R_3+\ldots+ R_{so}$

e) The calculated surface thermal conduction (convection) resistance values about outside wall;

R_i(m^{2}K/W) = 0,13

R_e(m^{2}K/W) = 0,04

f) Thermal Transmittance Coefficient U-Value (W/m^{2}K) ; $U= \frac{1}{R_i+R_1+R_2+\cdots+R_o}$

g) Overall U-value: $U_O = \frac{A_1U_1+A_2U_2+A_3U_3+\ldots}{A_1+A_2+A_3+\ldots}$

h) Heat flow rate; Q= A x U_o x t x (T_i-T_o)

TS 825 Turkish thermal insulation standard is regulating nowadays heat insulation requirements of each region based on maximum acceptable U-value of building envelop.

Ankara is located in the 3rd degree day zone, so Uwall is 0.50, Uceling is 0.30, Ufloor is 0.45 and Uwindow is 2.4 (W/m^2K).

For the Aslanhane Mosque surface resistance and Uwall value can calculate;

Rwall= 0.13+1/0.50+0.03/0.087+0.04

Rwall= 1.94

U= 1/R= 0.50

According to TS 825 standards, the U value of the Aslanhane mosque wall, built in the 13th century, is appropriate. U value depends on conductivity of material and thickness of layer. The thickness of the Aslanhane Mosque outside wall is available.

Where:

R: Thermal permeability resistance (m2.K/W),

d: Thickness of the building component (m),

λ: Thermal Conductivity Calculation Value (W/m.K)

Λ: Thermal Conductance

R_i: Superficial thermal conduction resistance of the inner surface (m2.K/W),

R_e: Superficial thermal conduction resistance of the outer surface (m2.K/W)

A: Total area

t: unit time

T_i= indoor temperature T_o= outdoor temperature

Table 3. Energy Efficiency of Aslanhane (Ahi Şerafettin) Mosque

Feature	13. yy	Nowadays	Suggestion
Lighting	Multiple window openings at different heights on mosque facades provide ample daylight. However, this design can pose challenges at night or when there is insufficient light. Historically, oil lamps were used for night lighting in Ottoman mosques until the Classical period (Doğan, 2013).	There are now some large chandeliers that have been adapted to the mosque. The photographs show that they are out of keeping with the historic structure of the mosque and do not provide effective lighting. Similarly, the lighting system in the garden of the mosque is both inefficient and diminishes its historical significance.	According to (Atılgan & Enarun, 2018), led lighting was added to the existing chandelier with lanterns, and a lighting design was made by staying true to the original. However, since there is no fixed lighting in the Aslanhane Mosque, instead of chandelier integration, the led lighting can be hidden in the building elements to prevent the deterioration of originality.
Heating	The mosque was built using the masonry technique with wooden pillars. The stone walls provided thermal comfort in the mosque so there was no need for any other	Although it has thermal insulation resistance to TS 825 standards, it must be supported by an internal heating system suitable for today's conditions.	While underfloor heating is energy efficient, the presence of carpets in mosques raises hygiene concerns. Heated air can carry harmful organisms from carpets, potentially affecting respiratory health.

	heating system in the 13th century mosque.		Investigating this risk is essential before implementing heating systems in mosques.
Air Conditioning	Door openings in three different directions in the mosque create a positive effect on ventilation. The openings in the direction of the dominant wind help fresh air to enter the mosque both on the ground floor and in the section reserved for women, that is, from the 1st floor.	There has no extra air conditioner in this mosque. Natural ventilation is enough for this space. It can be thought that the wooden columns may have experienced a problem due to condensation in the winter months. However, this problem was easily eliminated in this mosque, which has an easily ventilated plan.	It may be recommended to measure the air quality on Fridays when the mosque is heavily used. On the other hand, if these openings are not kept under control during the winter months when the wind blows very hard, it may cause the mosque with a lack of heating to be affected worse.
Local materials, Spoiler materials (column capitals)	In the energy management part, not only the energy in the existing structure is removed from the management but also embodied energy should also be evaluated. Local materials were used in the building, that is, walnut and crushed stone were used as wood. In addition, the column capitals in the region from the Roman period are some of the elements used in the building.	The fact that the materials used are local is still important in terms of easy and cheap supply. Any repair or change can be facilitated.	The supply of local products in the new technological solutions to be added will be financially and ecologically sustainable.

Conclusions and Discussions

Built in the 13th century using local construction methods, the Aslanhane Mosque was assessed in general terms under today's sustainability principles and conclusions were drawn specifically for the energy management of the heating system.

Under the heading of environmental sustainability, the use of local and salvaged materials was the first step in creating a building with a low carbon footprint. In terms of environmental sustainability, it has many details on energy efficiency thanks to its traditional construction technique. The Aslanhane Mosque has a design compatible with the being area. Topography and climate are taken into consideration. As a result of the calculations made, the one-meter-thick stone wall meets the TS 825 standards in use today. The thick stone walls are very successful in keeping the heat inside and at the same time not transferring the hot air coming from outside in the summer months. Small windows at various heights provide the minimum amount of daylight required for places

of worship. This also minimizes thermal bridging, preventing heat loss for the mosque, which does not have a dynamic heating system. and small windows also allow in daylight, preventing the interior of the mosque from overheating. The mosque, which has three entrances, has natural air circulation, eliminating problems such as humidity and overheating.

It is understood that the word sustainability, which entered the literature in the 19th century, and the principles of sustainability that developed from it, actually existed centuries before our time. Today, it has been found that some of the buildings we have certified to standards such as TS825 actually met the thermal insulation requirements of the building from the outset when built using local techniques. As the world changes and technology develops, new materials and techniques have come into our lives, but passive energy management can be done with the lessons learned from the buildings on the UNESCO World Heritage List.

In future studies, it can be mentioned how a new lighting and heating system will work in this area and how its efficiency will be analysed with digital methods and technical devices. In this way, an existing building can be sustainably adapted to today's situations. Presenting concrete analyses based on the results of this study will guide historical studies in a similar situation.

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