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Examining the Contribution of Transparency Ratios to the Central Space in Mimar Sinan Mosques in Istanbul and Edirne

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Abstract

Mimar Sinan was an architect beyond his time by the innovations he brought into the field of architecture in the Ottoman period from the middle of the 16th century to the end. The mosques he built in this period have been analyzed by many researchers today, in terms of their aesthetic values, cultural features, and technical perfection. As far as the researches are analyzed, it has been understood that no analytical study on transparency ratios has been conducted. By the solutions which are brought by Mimar Sinan for the central and collective space, the carrying feature of the walls has decreased and thus the transparent surfaces disposed on the façade have increased. At this point, it is important to conduct analytical studies examining the transparency ratios in Mimar Sinan's mosque designs. In this study, it is aimed to determine the transparency ratios of a total of fifteen buildings, fourteen in İstanbul and the Selimiye Mosque in Edirne, which all have a central plan scheme, and also to analyze the contribution of these ratios to the central space. Within the framework of the stated purpose, the contribution of the transparency ratios of Mimar Sinan mosques in Istanbul and Edirne to the central space was investigated by comparative analysis method. The contribution of the transparency ratios to the central space of the Mimar Sinan mosques in Istanbul and Edirne is investigated by comparative analysis method within the scope of the framework of the stated purpose.

1. INTRODUCTION

Mimar Sinan, who had lived during the 16th century in the Ottoman Empire, became one of the most prominent architects of history with his legacy of monumental works. During the Classical Ottoman Period, he constructed many significant masterpieces that pushed Turkish mosque architecture to its peak. The Şehzade Mosque, the Süleymaniye Mosque and the Selimiye Mosque which are named as his apprenticeship, journeyman, and mastership works, are accepted as his most important artifacts. When the mosques he had built are examined, it is seen that Sinan tried to develop the concept of central space. Particularly by the Selimiye Mosque, the concept of central space, which had been going on since the pre-Islamic period, reached its peak.

When designing mosques, Sinan not only used the traditional plan schemes but also brought innovations to many of them and made big contributions to the development of the concept of central space. Accordingly, a total of fifteen mosques with the concept of central dome, of which fourteen are from Istanbul and the Selimiye Mosque from Edirne, are included within the scope of the study.

The transparency ratio refers to the ratio of architectural elements that transmit natural light such as windows used in the design of the space to the total surface area. The development of the structural system in the Classical Period mosques led to the opportunity to open more windows on the wall surfaces by transferring the load from the walls to the pillars. Accordingly, within the context of the hypothesis of the study, it is expected that the transparency ratio of the selected mosques should increase in correspondence to the development of space. In this study, the transparency ratios of fifteen buildings

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included in the content are stated and the connection between Sinan's perception of central space and these ratios is analyzed.

In this research, after reviewing the literature, the plans, sections and façade drawings of the selected buildings were obtained and their one-to-one scale plan and façade drawings were comprised by transferring them to the AutoCAD program. By using these drawings, the transparency ratios of the buildings were determined separately for each façade.

Following that, the total transparency ratios of the buildings were calculated by taking the ratio of the total surface area of the façades to the transparent surface areas as a percentage. Tables were prepared by using the comparative analysis method in line with the information obtained. In the next phase, the contribution of transparency ratios to the concept of central space was examined, by evaluating these tables which are ordered chronologically and according to the transparency ratios.

By reviewing the literature, the opinions of the researchers about the use of windows in Mimar Sinan's mosques are included in the study. Tezel states that Mimar Sinan uses walls as a curtain and lighting tool in his buildings, thus he changes the style of using fewer windows on the load-bearing walls. She says that he makes religious buildings luminous by bringing them off dark places [1]. Egli emphasizes that, the Edirnekapı Mihrimah Sultan Mosque is highly luminous due to the multiple number of windows inside the large arches in the drum of the central dome [2]. Bolak expresses that, in the Şehzade, Süleymaniye and Selimiye mosques, the degree of light, the size and the number of windows are increased. Additionally, he expresses that together with the development of architecture, the development of lighting is also achieved [3,4].

When the studies including the transparency ratio in historical mosques are examined, Ataköy's master's thesis titled "Daylight Illumination in Mosques and Case Studies" is encountered solely. In the study, the transparency ratios of Kılıç Ali Paşa Mosque, Bebek Mosque and Barbaros Mosque in Istanbul are determined by the façade drawings. As a result of the study, it is determined that the transparent areas in the building envelope play a role in the homogenous distribution of the light [5].

2. MIMAR SINAN MOSQUES WITH CONCEPT OF CENTRAL SPACE IN ISTANBUL AND EDIRNE

The type of plan that emphasizes the center of the building, consisting of a domed main space carried by pillars and expanded by vaults or domed sections towards the sides is called the "Central Plan Scheme". The first example of this plan type is the Degaron Mosque built in the Karakhanid Period at the beginning of the 11th century [6,7]. According to many historians, the concept of central space is thought to have started with the Talhatan Baba Mosque, a Karakhanid building. This scheme, which was first seen in Anatolia with the Tokat Garipler Mosque in 1074, a Danismentli monumental work, is not known to have been repeated until the Old Fatih Mosque in 1463 [8].

The Old Fatih Mosque was formed by adding one half and two small domes to the south side of the central dome. To achieve the symmetry of the Old Fatih Mosque from both directions, one half and two small domes were added to the northern direction, resulting in the Beyazıt Mosque in Istanbul. Üsküdar Mihrimah Mosque was formed by adding a half dome to the east, west and south sides of the central dome, and Şehzade Mehmet Mosque with four half domes was formed by adding a half dome to the north. Following the Şehzade Mehmet Mosque, six-pillar and eight-pillar mosques were built, and structural principles were established to completely eliminate the side naves. As a result, this line of development came to an end with the construction of the Selimiye Mosque, where the concept of a unitary and collective space without side naves and half domes reached its climax [9].

The mosque was formed by expanding the domed main space with three half domes in the east, west and north directions and two small domed sections in the corners. The central dome is carried by two pillars adjacent to the wall and two free-standing pillars. Later, the Şehzade Mosque was built in Istanbul between 1543 and 1548 [10]. The structure is formed by expanding the main domed space with a half

dome on four sides and four small domes at the corners. The central dome is carried by four free-standing pillars. It is understood that Sinan made different experiments in the process leading to the centralization of the domed main space, using three half domes in Üsküdar Mihrimah Sultan Mosque and four half domes in Şehzade Mosque [9]. The domed main space started to become more central with the addition of half domes in four directions.

Suleymaniye Social Complex was built in Istanbul between 1550 to 1557 [11]. Suleymaniye Mosque, located within the social complex, is formed by expanding the domed main space with two half domes to the south and north and five domed sections, large and small, on the side naves. The central dome is carried by four free-standing pillars. Süleymaniye Mosque is an improved and reformed repetition of the plan schemes of Hagia Sophia and Istanbul Beyazıt Mosque, with the addition of half domes to the south and north of the main domed space. The spatial integrity, which cannot be seen in the plan diagrams of these two buildings, was successfully achieved in the Süleymaniye Mosque by reducing and retracting the column between the main carriers, allowing the side naves to join the central space.

Sinan Paşa Mosque was built in Istanbul between 1553 and 1555 [12]. According to its restitution, the building is formed by expanding the domed main space with two small domed sections on each side. The central dome is supported by four pillars adjacent to the wall and two free-standing pillars. The mosque bears a great resemblance to Edirne Üç Şerefeli Mosque in terms of plan and covering system [12]. The building, which was repaired in various periods, was demolished in 1749, leaving large pillars on the north wall. The last congregation area of the building was added to the sanctuary and the arched openings in the last congregation area were closed by building a wall [13]. In the study, the building was evaluated according to the restitution situation in which the plan scheme was not distorted. With this mosque, it is understood that Sinan took the mosque scheme built in previous periods and reused it by bringing innovations. When the restitution plan is examined, it is seen that the sanctuary area of the building could not be fully centralized as it created a fragmented space with small domes on the side naves and useless triangular areas around the central dome.

Kara Ahmet Paşa Mosque was built in Istanbul Topkapı between 1554-58 [14]. The structure is formed by expanding the domed main space with four half-domed sections at its corners. The central dome is carried by six columns. The sanctuary area of the mosque, which is one of Sinan's six-pillar structures, is formed with large-sized half-dome sections at the corners, allowing the space to have a more holistic structure instead of being divided into side naves. This shows that this building is one of the important attempts to reach a unitary and collective space in concepts of central space.

Molla Çelebi Mosque in Istanbul was built in 1561-1562 [15]. The mosque was formed by adding four semi-domes to the corners of the domed main space and a semi-domed mihrab niche to the south. The central dome is supported by four pillars adjacent to the wall and two free-standing pillars. Like the Kara Ahmet Pasha Mosque, Molla Çelebi Mosque is one of Sinan's structures with six pillars. Unlike the Molla Çelebi Mosque, the addition of a mihrab niche emphasizes the mihrab direction as well as the central space.

Rüstem Paşa Mosque, famous for its tile revetments, was built in Istanbul in 1561-1562 [12]. The building is formed by expanding the domed main space to the sides with vaulted sections on the inside and domes on the outside. The central dome is supported by four free-standing pillars and four pillars adjacent to the wall. In the mosque, which is one of Sinan's eight-pillar structures, the naves next to the central dome have made the sanctuary area more fragmented. On the other hand, Sinan made significant progress in the centralization of the main space by using eight pillars to support the central dome, making it completely independent of the wall.

Edirnekapı Mihrimah Sultan Mosque was built in Istanbul between 1562-65 [12]. The mosque is formed by expanding the main domed space, supported by four pillars adjacent to the walls, with small domed sections to the sides. The building differs from Sinan's other buildings with the series of windows on the drum of the dome, which is raised by four large arches. Many sources emphasize that this is Sinan's building with the most windows [2].

Selimiye Mosque in Edirne, considered Sinan's peak work, was built in 1568-74 [16]. The mosque is formed by adding a mihrab niche to the south of the domed main space. The central dome is supported by six large-sized free-standing pillars and two pillars adjacent to the wall. Thanks to the pillars supporting the dome, the structural system has become completely independent from the wall; The worship area is gathered under the central dome, creating a unitary and collective space. Avoiding the use of side naves and half domes, which disrupt the integrity of the sanctuary area, enabled the central space concept to reach its peak in the Selimiye Mosque.

Eski Valide Mosque in Istanbul was built twice during the time Sinan was the chief architect. When the mosque was built between 1570-75, it had a hexagonal plan in the middle section. According to this plan scheme, the building was formed by adding four semi-domes to the corners of the domed main space and a semi-domed mihrab niche to the south. Later, in 1582, the building was enlarged by adding side naves with two domes on both sides of the mihrab to expand the sanctuary. In 1834, the portico dome adjacent to the mosque in the south corner was canceled and the sultan's lodge was added to this corner [17]. There are different opinions about the mosque's architect. Since it is known that Mimar Sinan was the chief architect during the first two construction periods of the building, it is believed that the mosque was built by him [18]. When looking at the restitution plans in Necipoğlu's book, it is understood that the building had a central plan type in both plan schemes of 1570-75 and 1582 [19]. The central dome is supported by four pillars adjacent to the wall and two columns. In the study, the plan and façade features of the building in 1582 were evaluated. The side naves added to both sides of the domed space during the second construction period of the building disrupted the integrity of the sanctuary.

Kadırga Sokullu Mehmet Paşa Mosque in Istanbul was built in 1572 [20]. The structure is formed by adding four semi-domes to the corners of the main domed space supported by six pillars adjacent to the wall. The use of half domes in the mosque, which is one of Sinan's six-pillar structures such as the Kara Ahmet Paşha Mosque and Molla Çelebi Mosque, contributed to the formation of a more collective and central space.

Zal Mahmut Paşa Mosque was built in Istanbul in 1577-80 [21]. The mosque is formed by expanding the domed main space with vaulted and domed naves on both sides and towards the entrance. The central dome is supported by two pillars adjacent to the wall and two free-standing pillars. The side naves added to the east, west and north of the domed space distorted the perception of the collective space. The use of four rows of windows on the side façades of the mosque differentiated it from Sinan's other works.

Azapkapı Sokullu Mehmet Paşa Mosque was built in 1577-78 [22]. The domed main space of the building, including the mihrab niche, is surrounded by a semi-dome in four directions and four squinches at the corners. The side naves are covered with a small dome at the corners and vaults in the remaining sections. The central dome is supported by a total of eight pillars, six of which are free-standing and two of which are adjacent to the wall. Looking at the placement of the half and small domes added to the four sides of the main dome, it can be thought that Sinan made different attempts to expand the sanctuary.

Kılıç Ali Paşa Mosque was built in Istanbul in 1580 [23]. The mosque is formed by adding two semi-domes to the south and north of the domed main space, and small domed and cross-vaulted naves to the east, west and north. The central dome is supported by four free-standing pillars. With this mosque, Sinan reused the basilical scheme he used in the Süleymaniye Mosque, which he built between 1550 and 1557, by adding a mihrab niche and front nave. The use of many semicircular arched windows on the side façades of Kılıç Ali Paşa Mosque creates a different appearance from the Süleymaniye Mosque.

Nişancı Mehmet Paşa Mosque in Istanbul was built between 1584-88 [24]. The building consists of a semi-dome in four directions, including the mihrab niche of the domed main space, and four squinches at the corners. The central dome is supported by eight pillars adjacent to the wall. When we look at the layout of the half and small domes added to the four sides of the main dome and the eight pillars plan scheme, it can be seen that it has similar features to the Azapkapı Sokullu Mehmet Paşa Mosque. On the other hand, the fact that the building has a recessed form on all four sides reflects a different architectural approach from Sinan's other works. In this structure, the absence of elements such as corner domes and

vault naves in the Azapkapı Sokullu Mehmet Paşa Mosque made the interior more centralized and ensured a holistic perception of the space.

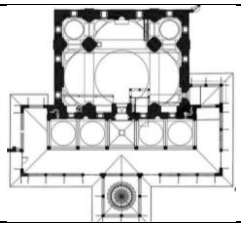
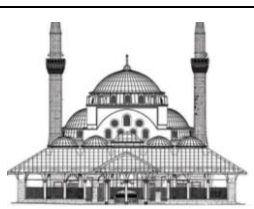
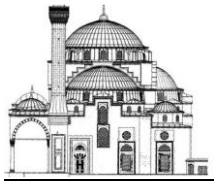
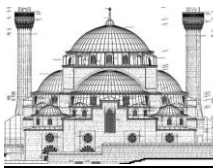
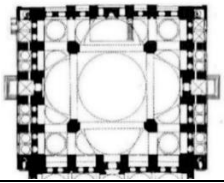
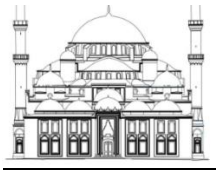
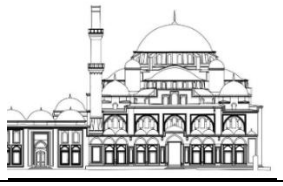
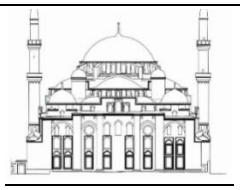
When we look at Sinan's buildings in Istanbul and Edirne with a central space approach in general, it can be seen that in the examples until the Selimiye Mosque, there is a unitary and collective space development that is attempted to be created with a plan, structure and cover system. When the line of development of Turkish mosque architecture is examined, it is understood that the concept of a unitary and collective central space has reached its peak when the approximately 31.5-meter main dome of the Selimiye Mosque was supported by free-standing pillars and the side naves were eliminated. When we look at the mosques that Sinan built after the Selimiye Mosque, it is seen that he repeated the schemes he had used before, bringing some innovations to the plan and façade layout.

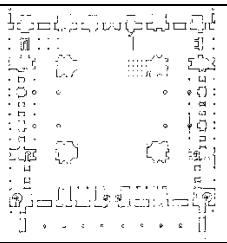
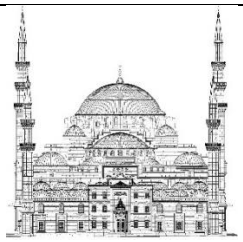
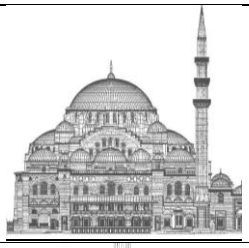
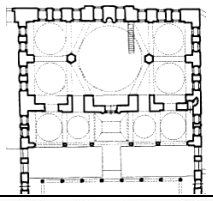
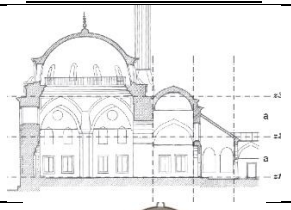
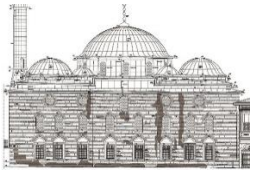
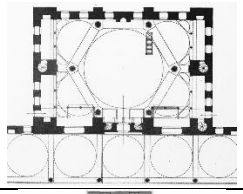
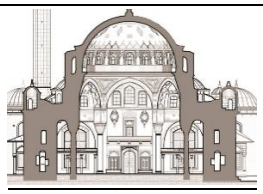
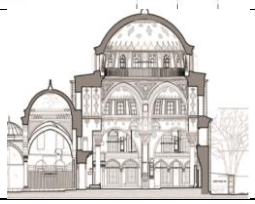
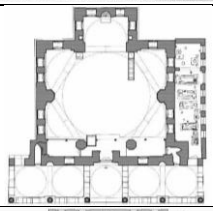
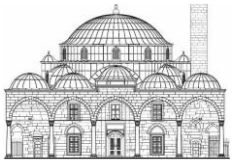
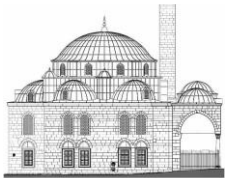
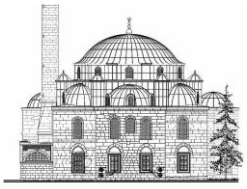
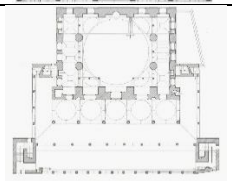
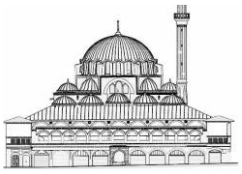
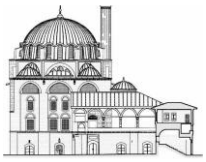
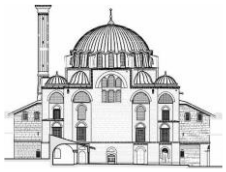
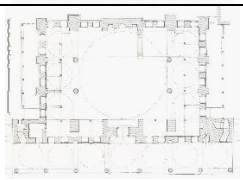
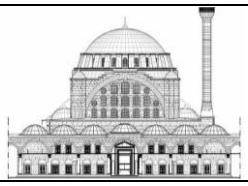
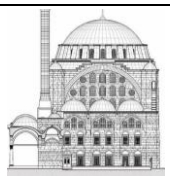
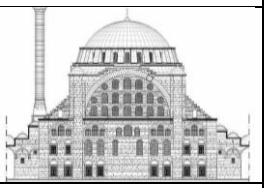
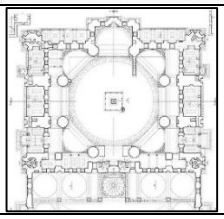
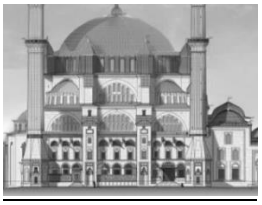
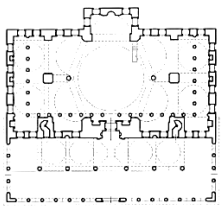
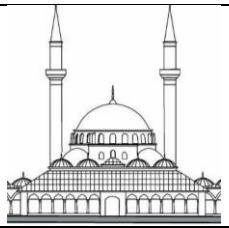
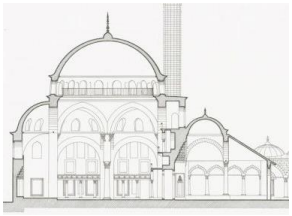
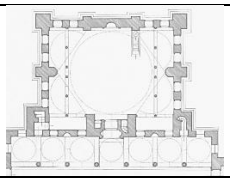
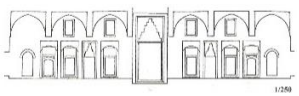
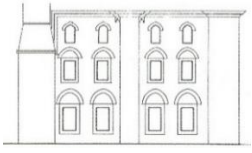
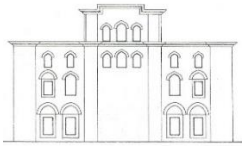
When we look at the façades of Sinan's mosques with a central plan scheme, there is a very plain and simple façade design. The façade design of the buildings is generally created by gradually elevating the main wall, dome drum, squinch, exedra, half dome, buttress and central dome. In some of the buildings, a hipped-roofed portico surrounds the last congregation area on the north side, which is the entrance. This portico layout is found in Üsküdar Mihrimah Sultan Mosque, Sinan Pasha Mosque, Rüstem Pasha Mosque, Edirnekapı Mihrimah Sultan Mosque, Eski Valide Mosque and Kılıç Ali Pasha Mosque. There are fewer and smaller windows on the entrance façade of the buildings compared to the other façades. The side façades are designed to be in symmetry with each other. While some buildings have more window openings on the mihrab façade, some have more window openings on the side façades.

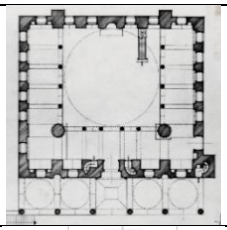
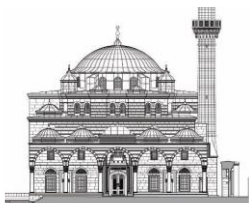
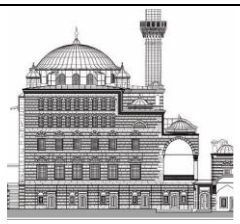
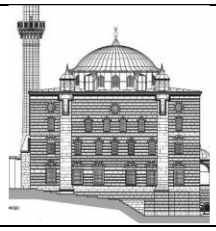
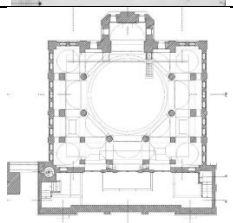
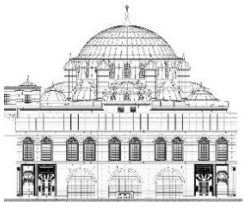
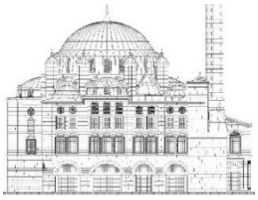
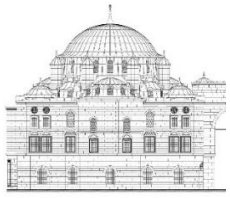
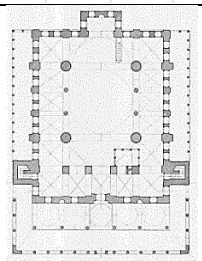
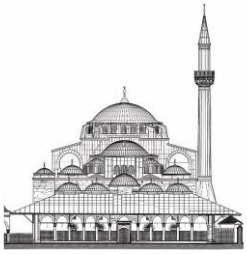
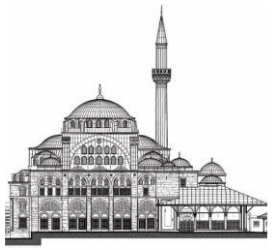
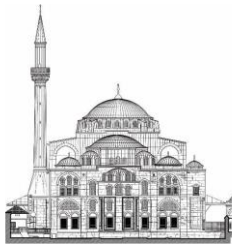
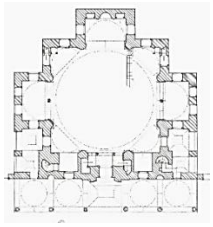
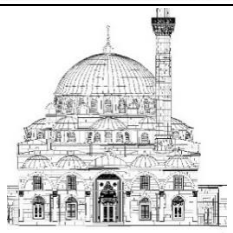
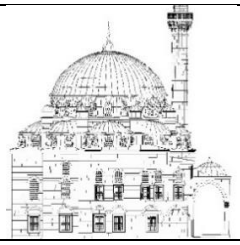
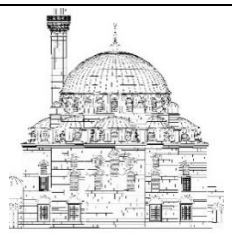
Unlike other buildings, there are two or three rows of windows at the lower level of the arch carrying the central dome in Üsküdar Mihrimah Sultan Mosque, Süleymaniye Mosque, Edirnekapı Mihrimah Sultan Mosque, Selimiye Mosque and Kılıç Ali Paşa Mosque. Windows are generally placed on three floors in the main walls of the buildings: lower, lodge and upper levels. Zal Mahmut Paşa Mosque and Kılıç Ali Paşa Mosque have a window arrangement on four floors on the side and mihrab façades, while Kara Ahmet Paşa Mosque and Molla Çelebi Mosque have a window arrangement on two floors. Unlike other buildings, there are large windows extending over two floors on both sides of the portal entrance of Kara Ahmet Paşa Mosque and Rüstem Paşa Mosque. Rüstem Paşa Mosque and Kılıç Ali Paşa Mosque differ from other mosques by having large semicircular windows on the side and mihrab façades.

When we look at the window openings in the covering system of the buildings in general, it is seen that arched windows are used on the skirts of squinches, exedra, central domes and semi-domes. Plans, sections and façade drawings of the buildings were obtained from the archives of Ali Saim Ülgen and the General Directorate of Foundations, the theses of Gürbüz, Özyalvaç, Mohtasıb, the websites of PC Yapı Mimarlık Restorasyon, FOCUS Restorasyon Mimarlık and Avunduk Architecture Offices and Erzen's book [25, 26, 27, 15, 28, 29, 30, 31, 32]. Table 1 was created from the obtained plan, section and façade drawings.

Table 1. *Plans, sections and façades of drawings of the mosques in the study*

Name of Building	Plan	Entrance Façade / Section	Side Façade / Section	Mihrab Façade
Mihrimah Sultan Mosque (Üsküdar), 1540-1548 [25,27]				
Şehzade Mosque, 1543-1548 [15,28]				

Süleymaniye Mosque, 1550-1557 [26]				
Sinan Paşa Mosque, 1553-55 [29,32]				
Kara Ahmet Paşa Mosque, 1554-58 [30,32]				
Molla Çelebi Mosque, 1561-62 [15]				
Rüstem Paşa Mosque, 1561-62 [15,25]				
Mihrimah Sultan Mosque (Edirnekapı), 1562-1565 [15]				
Edirne, Selimiye Mosque, 1568-1574 [31]				
Eski Valide Mosque, 1570-75 [15, 25]				
Kadırga Sokullu Mehmet Paşa Mosque,1572 [25,32]				

Zal Mahmut Paşa Mosque, 1577-80 [15,25]				
Azapkapı Sokullu Mehmet Paşa Mosque, 1577-78 [26]				
Kılıç Ali Paşa Mosque, 1580 [15,25]				
Nişancı Mehmet Paşa Mosque, 1584-1588 [26]				

3. CONTRIBUTION OF TRANSPARENCY RATES OF MIMAR SINAN MOSQUES IN ISTANBUL AND EDIRNE TO THE CENTRAL SPACE

Transparency ratio generally refers to the ratio of windows or other transparent architectural elements used in the design of a building or space to the total wall area. This ratio is used to assess the visual connection between the interior and exterior of a building and its light transmission. Buildings with a high transparency ratio allow more natural light to enter the interior spaces and better visibility of the views outside. Transparency has a significant impact on the functionality and aesthetics of architectural design.

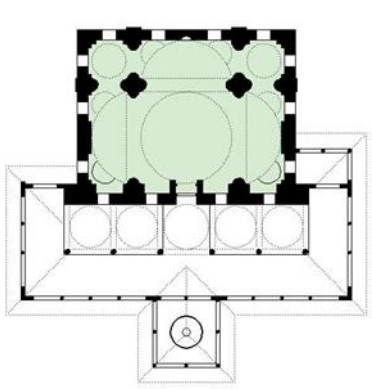
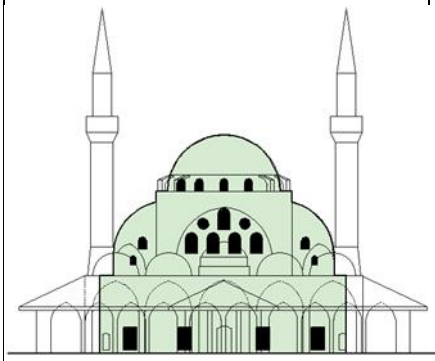
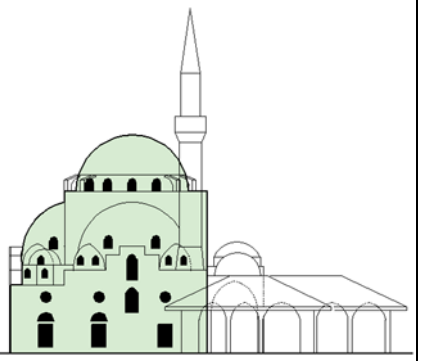
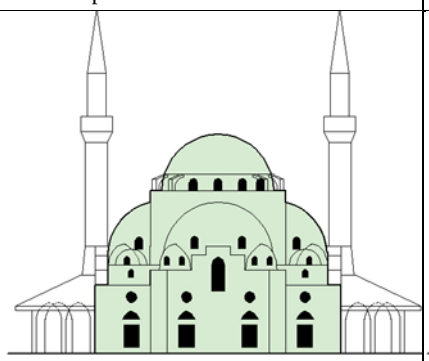
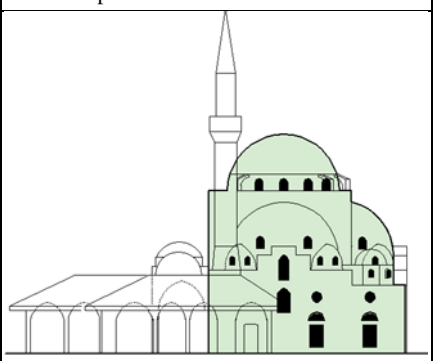
The transparency ratios of the buildings were determined from the plans, sections and façade drawings obtained from the literature review. These drawings were transferred to the AutoCAD program and the plan and façade drawings were schematically created in one-to-one scale. In the façade drawings, the boundary lines of the façade and cover elements forming the interior space were determined and the surface areas of these façade lines were calculated. Afterwards, the frames of the windows illuminating the interior space on the four façades of the buildings were drawn as polyline and the surface areas were determined for each façade individually by assigning hatching to these frames. The ratio of these surface areas to the total surface area of the façade was calculated as a percentage.

Since the windows in the main walls are located in the same plane as the façade plane, it is possible to access the actual dimensions of the transparent surfaces through the façade drawings. On the other hand, some of the windows in the dome, half dome and transition to the dome in the covering system are located on different planes than the façade planes. This means that the projection areas of these windows in the façade drawings constitute less transparent surface areas than their actual dimensions. In particular, windows placed at an angle of 45 degrees to the façade are not visible in the drawings because they do not project onto the façade plane due to their positions. To obtain more accurate data, in this study, the actual surface areas of the windows in the covering system were drawn schematically and distributed

equally or almost equally to all façades. With this method, the transparency ratios of all buildings were determined.

In the sample calculation in Table 2, the twenty windows in the central dome of Üsküdar Mihrimah Sultan Mosque were placed on the façades as four each in a one-to-one scale, provided that the position and symmetry of the windows are not disturbed. In the building, which has three half domes, four windows in each half dome are distributed on the façades as 1-2-1 respectively. The three windows in each of the six squinches were placed on the façades as 1-2. Accordingly, while the surface area of the mihrab façade is approximately 511.5 m², the total surface area of the windows placed on this façade is approximately 45.5 m². The ratio of the surface area of the windows to the surface area of the façade was calculated to be approximately 8.9%. This ratio represents the transparency rate of the mihrab façade. The transparency ratios of all other façades were determined by the same method. The transparency rates of the mosque were calculated as 7.8% on the north façade, 7,9% on the east façade, 9,1% on the south façade and 6.9% on the west façade. Similarly, the total transparency rate of the façades was determined by taking the ratio of the total surface area of the four façades to the total transparent surface area as a percentage. This ratio was calculated as approximately 7.9%. These calculations are detailed in Table 2. Similar calculations were made for the façades of the other fourteen buildings and the information obtained was converted into tables. The plan and façade drawings of the buildings created in the AutoCAD program and the transparency ratios determined from these drawings are given in Tables 3 and 4.

Table 2. *Transparency rates of Üsküdar Mihrimah Sultan Mosque*

Plan of the Building	North Façade (Entrance)	East Façade
	 The surface area of the façade: ~ 514.8 m2 Transparent surface area: ~ 39.9 m2	 The surface area of the façade: ~ 439.9 m2 Transparent surface area: ~ 34.8 m2
Total Transparency Ratio Calculation of Façades The total surface area of the façades: 514.8+439.9+511.5+439.9=1906.1 m2 The total area of transparent surfaces: 39.9+34.8+46.6+29.8=151.1 m2 (151.1x100) /1906.1= ~ 7.9% Transparency Rates All fronts ~7.9% North Façade ~7.8% East Façade ~7.9% South Façade ~9.1% West Façade ~6.8%	 The surface area of the façade: ~ 511,5 m^2 Transparent surface area: ~ 46,6 m^2	 The surface area of the façade:~ 439,9 m^2 Transparent surface area: ~ 29,8 m^2
Transparency Ratios	South Façade (Mihrap)	West Façade

In Ataköy's study on the transparency rate in historical mosques, he determined the transparency rates of Kılıç Ali Paşa Mosque as 6% for the north façade, 19% for the east façade, 18% for the west and south façades and the average transparency rate of all façades as 15%. In the study, while the windows in the main walls were proportioned to the total surface area of the façades, the twenty-four windows in the dome drum were calculated to be equal to the façades by proportioning the dome surface area. In

addition, to determine the transparency ratios of the façades, the averages of the façade ratios were taken [5]. In addition, the surface areas of the elements of the covering system that make up the interior space in the façade drawings should also be included in the transparency ratio calculation. Looking at the façade drawings in Ataköy's study (Figure 1), it is seen that the half dome in the mihrab niche, the small domes on all four façades and the main walls of the right section on the east façade are not included in the transparency ratio calculation. This makes the building more transparent than it actually is. Since the arched windows on the entrance façade are not included in the ratio calculation, the north façade has a lower transparency ratio.

In this study, all the main walls forming the sanctuary and architectural elements such as dome, half dome, small dome, and squinch in the covering system were determined by thickly determining the boundaries on the façade drawings and the total surface areas of the façades were determined (Figure 2). In the inclusion of the windows in the covering system in the transparent surface areas of the façades, the twenty-four windows in the central dome were distributed to the façades as six each in a one-to-one ratio. The five windows of each of the two squinches in the two half domes were distributed as two windows each on the entrance and mihrab façades and three windows each on the side façades. In addition, to provide more accurate data in determining the transparency ratios of the façades, instead of taking the averages of the façade ratios, the total surface area on the four façades was proportioned to the total transparent surface area. Accordingly, the transparency ratios of the mosque were calculated as 7.6% on the north façade, 18.2% on the east façade, 15.8% on the south façade, 18.2% on the west façade and 15.4% on all façades.

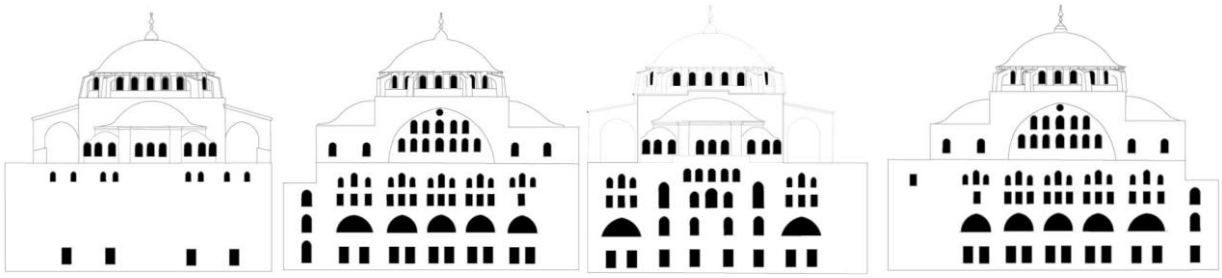


Figure 1. *Transparent surface areas determined on the north, east, south and west façades of Kılıç Ali Paşa Mosque in the study in Ataköy (Ataköy, 2018*)

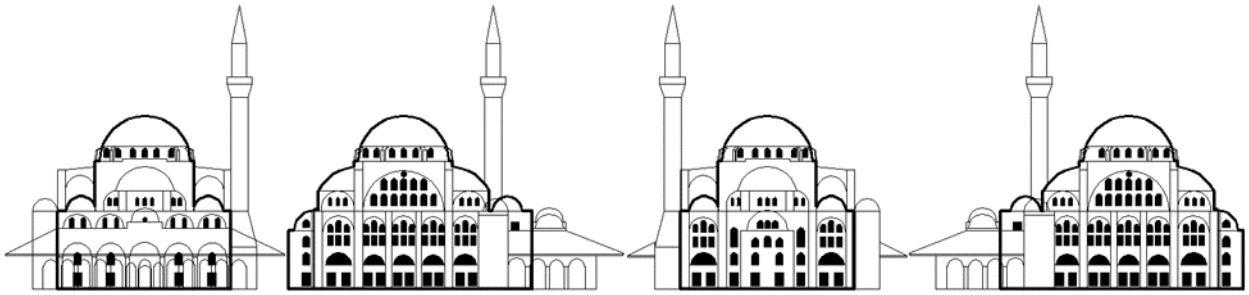


Figure 2. *Transparent surfaces and the boundaries forming the interior space determined on the north, east, south and west façades of the Kılıç Ali Paşa Mosque examined within the scope of the study*

When Table 3, which chronologically includes the buildings from Üsküdar Mihrimah Sultan Mosque to Rüstem Paşa Mosque, is examined, it is seen that the transparency rate of all façades of Üsküdar Mihrimah Sultan Mosque is approximately 7.9%, while this rate is approximately 9.9% in Şehzade Mosque. In Süleymaniye Mosque, this rate is approximately 10.3%, in Sinan Paşa Mosque 10.8%, in Kara Ahmet Paşa Mosque 10.4%, in Molla Çelebi Mosque 8.5%, and in Rüstem Paşa Mosque 14.5%. When Table 4, which chronologically includes the buildings from Edirnekapı Mihrimah Sultan Mosque to Nişancı Mehmet Paşa Mosque, is analyzed, it is seen that the transparency rate of all façades in Edirnekapı Mihrimah Sultan Mosque is approximately 17.4%. It is understood that Edirnekapı Mihrimah Sultan Mosque has the highest transparency rate among the other buildings examined within the scope of the study. This rate was calculated as 9.4% in Edirne Selimiye Mosque, 11.3% in Eski Valide Mosque,

12.1% in Kadırga Sokullu Mehmet Pasha Mosque, 14.8% in Zal Mahmut Pasha Mosque, 15.7% in Azapkapı Sokullu Mehmet Pasha Mosque, 16.2% in Kılıç Ali Pasha Mosque and 10.6% in Nişancı Mehmet Pasha Mosque.

When the graph (Figure 3), which chronologically ranks the transparency ratios of the buildings, is examined, it is observed that there is a proportional increase until Edirnekapı Mihrimah Sultan Mosque, while the transparency ratios of the buildings after this building change within a certain range. When we rank the Şehzade Mosque, Süleymaniye Mosque and Selimiye Mosque, which are the apprenticeship, journeyman and mastership of Mimar Sinan, according to the transparency ratio, Süleymaniye Mosque, Şehzade Mosque and Edirne Selimiye Mosque come from the highest to the lowest. When these three buildings are compared according to the number of windows, it is seen that Süleymaniye Mosque has the most windows and Edirne Selimiye Mosque has the least windows.

Bolak's [3] opinion that "the size and number of window openings increased in Şehzade, Süleymaniye and Selimiye mosques, which Sinan called his apprenticeship, journeyman and masterpiece" does not fit with these data. From this point of view, it is understood that this subjective discourse based on visual perception mentioned by Bolak does not comply with the objective and analytical results obtained in the study.

When Table 5 is analyzed according to the transparency ratio of the buildings, it is understood that the building with the highest transparency ratio by far is Edirnekapı Mihrimah Sultan Mosque. This mosque is followed by Azapkapı Sokullu Mehmet Pasha Mosque, Kılıç Ali Pasha Mosque, Zal Mahmut Pasha Mosque, Rüstem Pasha Mosque, Kadırga Sokullu Mehmet Pasha Mosque, Eski Valide Mosque, Sinan Pasha Mosque, Nişancı Mehmet Pasha Mosque, Süleymaniye Mosque, Kara Ahmet Pasha Mosque, Şehzade Mosque, Edirne Selimiye Mosque, Molla Çelebi Mosque and Üsküdar Mihrimah Sultan Mosque.

When the transparency rates of Edirnekapı Mihrimah Sultan Mosque, which has the highest transparency rate, on the entrance and mihrab façades are compared with other buildings, it is understood that it has the most transparent surface on these façades as well. Zal Mahmut Pasha Mosque has the highest transparency rate with 18.6% on the east and west façades, which are the side façades. This rate represents the highest transparency value compared to all other façades and façade averages.

When we compare the buildings in terms of façade planes, it is seen that the transparency rate on the west façade of Üsküdar Mihrimah Sultan Mosque, which has the lowest transparency rate, has the lowest rate compared to other buildings. It is understood that Molla Çelebi Mosque has the lowest transparency rate on the south façade, Kara Ahmed Paşa Mosque and Üsküdar Mihrimah Sultan Mosque on the east façade, and Süleymaniye Mosque on the north façade. Looking at these rates on all façades, it is seen that the north façade, which is the entrance façade of the Süleymaniye Mosque, has the lowest transparency rate with 5.2%.

When the buildings are compared according to the difference between the transparency ratios of the façades, it is observed that Kılıç Ali Paşa Mosque has the highest difference with a rate of 10.6%, while Rüstem Paşa Mosque and Selimiye Mosque have the least difference with a rate of 1.3%. Zal Mahmut Pasha Mosque, Süleymaniye Mosque, Sinan Pasha Mosque, Nişancı Mehmet Pasha Mosque, Azapkapı Sokullu Mehmet Pasha Mosque, Kara Ahmet Pasha Mosque, Kadırga Sokullu Mehmet Pasha Mosque, Şehzade Mosque, Edirnekapı Mihrimah Sultan Mosque, Molla Çelebi Mosque and Üsküdar Mihrimah Sultan Mosque follow these buildings, respectively. When we rank Şehzade Mosque, Süleymaniye Mosque and Selimiye Mosque, which are the most important works of Mimar Sinan, according to the difference in transparency ratios between the façades, Süleymaniye Mosque, Şehzade Mosque and Edirne Selimiye Mosque come from the highest to the lowest.

When the relationship between the transparency ratios of the fifteen buildings within the scope of the study and the central space is examined, a direct proportion between the development of the central space and the transparency ratios could not be determined. In the development of the concept of the central

space, with the increase in the number of pillars carrying the dome, the walls became independent in carrying the central dome, and thus the main walls acted as a curtain and allowed for the opening of many window openings. According to this situation, it is expected that the transparency rates of the buildings that contribute to the concept of central space will increase according to the architectural development. Looking at the graph in Figure 3, it is seen that there is no direct relationship between central space and transparency ratio. This is clearly understood by the fact that the eight-pillar Selimiye Mosque has one of the lowest transparency rates with 9.4%, while the four-pillar Edirnekapı Mihrimah Sultan Mosque has the highest transparency rate with 17.4%.

Although the Selimiye Mosque, Sinan's pinnacle work in the concept of central space, has a low transparency rate compared to other buildings, it is seen that it is among the buildings with the least difference in terms of transparency rates between the façades. According to this inference, it is thought that Sinan wanted to build a building in which the light is taken into the interior in a balanced way by leaving equal openings on all façades instead of constructing the building with the highest transparency ratio in the Selimiye Mosque, which he called his masterpiece. Accordingly, it is understood that Sinan had a different quest in the development of the central space and this should be addressed as the subject of another research.

***Table 3**. Transparency rates were calculated based on the plans and façades of the mosques in the study (from Üsküdar Mihrimah Sultan Mosque to Rüstem Paşa Mosque)*

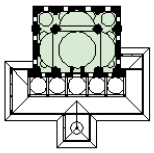
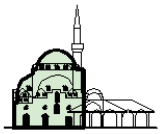
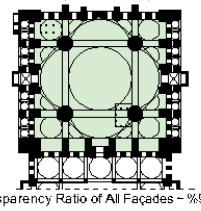
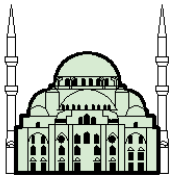
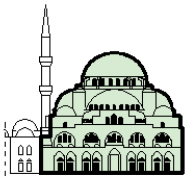
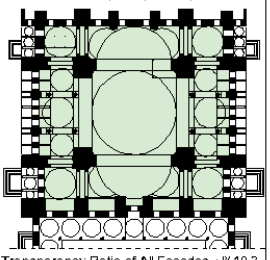
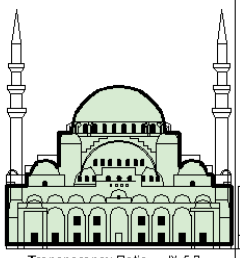
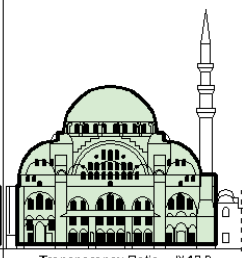
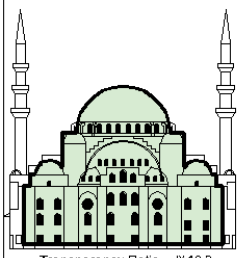
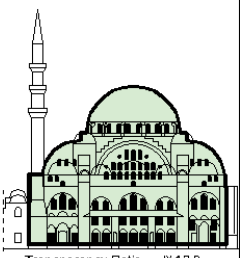
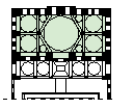
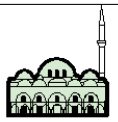
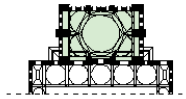
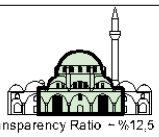
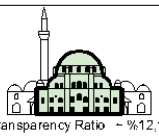
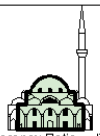
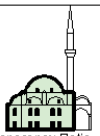
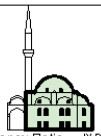
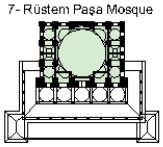
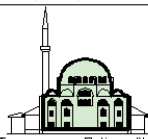
Plan of the Building	North Façade (Entrance)	East Façade	South Façade (Mihrap)	West Façade
1- Üsküdar Mihrimah Sultan Mosque  Transparency Ratio of All Façades ~%7,9	 Transparency Ratio ~%7,5	 Transparency Ratio ~%8,2	 Transparency Ratio ~% 8,9	 Transparency Ratio ~%6,9
2- Şehzade Mosque  Transparency Ratio of All Façades ~%9,9	 Transparency Ratio ~%9,1	 Transparency Ratio ~%9,8	 Transparency Ratio ~%11,0	 Transparency Ratio ~%9,8
3- Süleymaniye Mosque  Transparency Ratio of All Façades ~%10,3	 Transparency Ratio ~% 5,2	 Transparency Ratio ~%12,9	 Transparency Ratio ~%10,3	 Transparency Ratio ~%12,9
4- Sinan Paşa Mosque  Transparency Ratio of All Façades ~%10,8	 Transparency Ratio ~%7,4	 Transparency Ratio ~%11,3	 Transparency Ratio ~%13,5	 Transparency Ratio ~%11,3
5- Kara (Gazi) Ahmet Paşa Mosque  Transparency Ratio of All Façades ~%10,4	 Transparency Ratio ~%12,5	 Transparency Ratio ~%8,2	 Transparency Ratio ~%12,1	 Transparency Ratio ~%8,2
6- Molla Çelebi Mosque  Transparency Ratio of All Façades ~%8,5	 Transparency Ratio ~%7,4	 Transparency Ratio ~%9,1	 Transparency Ratio ~%8,6	 Transparency Ratio ~%9,1
7- Rüstem Paşa Mosque  Transparency Ratio of All Façades ~%14,5	 Transparency Ratio ~%14,2	 Transparency Ratio ~%14,2	 Transparency Ratio ~%15,5	 Transparency Ratio ~%14,2

Table 4. *Transparency rates were calculated from the plan and façades drawings of the mosques in the study (from Edirnekapı Mihrimah Sultan Mosque to Nişancı Mehmet Paşa Mosque)*

Plan of the Building	North Façade (Entrance)	East Façade	South Façade (Mihrap)	West Façade
8- Edirnekapı Mihrimah Sultan Mosque Transparency Ratio of All Façades ~%17,4	Transparency Ratio ~ %17,0	Transparency Ratio ~ %16,8	Transparency Ratio ~ %18,7	Transparency Ratio ~ %16,8
9- Edirne, Selimiye Mosque Transparency Ratio of All Façades ~%9,4	Transparency Ratio ~ %8,7	Transparency Ratio ~ %10,0	Transparency Ratio ~ %9,2	Transparency Ratio ~ %10,0
10- Üsküdar, Eski Valide Mosque Transparency Ratio of All Façades ~%11,3	Transparency Ratio ~ %9,7	Transparency Ratio ~ %10,6	Transparency Ratio ~ %13,5	Transparency Ratio ~ %10,6
11- Kadırga, Sokullu Mehmet Paşa Mosque Transparency Ratio of All Façades ~%12,1	Transparency Ratio ~ %11,0	Transparency Ratio ~ %11,6	Transparency Ratio ~ %13,0	Transparency Ratio ~ %11,6
12- Zal Mahmut Paşa Mosque Transparency Ratio of All Façades ~%14,8	Transparency Ratio ~ %9,1	Transparency Ratio ~ %18,6	Transparency Ratio ~ %13,8	Transparency Ratio ~ %18,6
13- Azapkapı, Sokullu Mehmet Paşa Mosque Transparency Ratio of All Façades ~%15,7	Transparency Ratio ~ %12,3	Transparency Ratio ~ %17,5	Transparency Ratio ~ %15,4	Transparency Ratio ~ %17,5
14- Kılıç Ali Paşa Mosque Transparency Ratio of All Façades ~%15,4	Transparency Ratio ~ %7,6	Transparency Ratio ~ %18,2	Transparency Ratio ~ %15,8	Transparency Ratio ~ %18,2
15- Nişancı Mehmet Paşa Mosque Transparency Ratio of All Façades ~%10,6	Transparency Ratio ~ %6,9	Transparency Ratio ~ %11,8	Transparency Ratio ~ %12,2	Transparency Ratio ~ %11,8

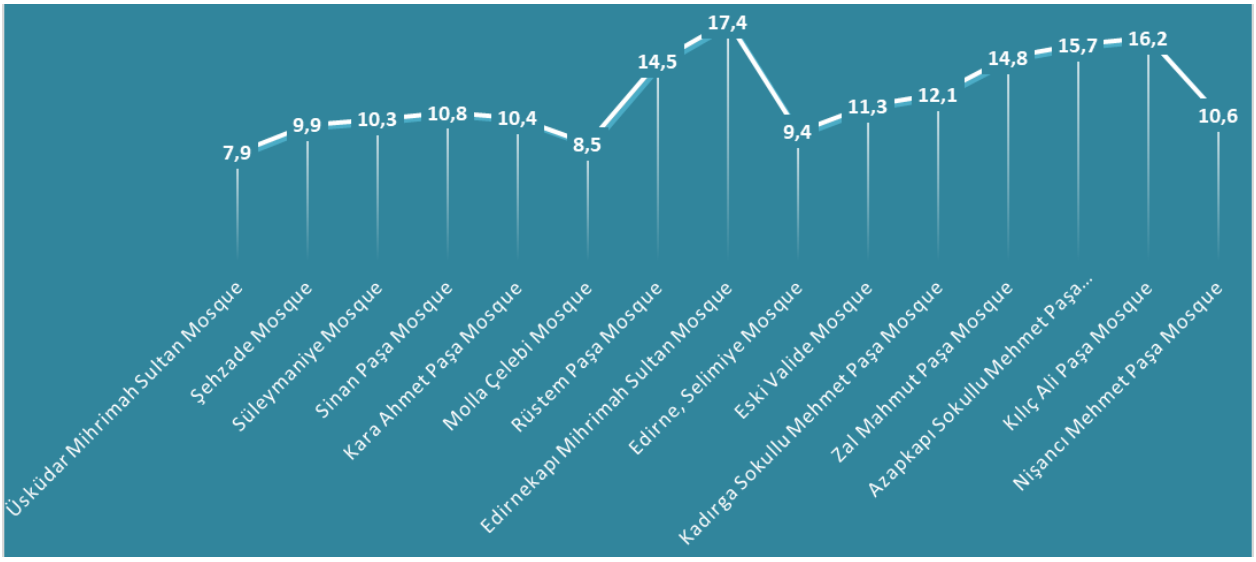


Figure 3. *Chronological change graph of transparency rates of the mosques included in the study*

Table 5*. Ranking of the mosques in the study according to their transparency rates*

Transparency Ratios	Name of Building	Date of Construction	Transparency Ratios (Glass Surface Ratio %)					
			North Façade (Entrance)	East Façade	South Façade (Mihrap	West Façade	All Façades	Difference Between Façades
↑	Edirnekapı Mihrimah Sultan Mosque	1562-1565	**17**	16,8	**18,7**	16,8	**17,4**	1,9
	Azapkapı Sokullu Mehmet Paşa Mosque	1577-1578	12,3	17,5	15,4	17,5	15,7	5,2
	Kılıç Ali Paşa Mosque	1580	7,6	18,2	15,8	18,2	15,4	**10,6**
	Zal Mahmut Paşa Mosque	1577	9,1	**18,6**	13,8	**18,6**	14,8	9,5
	Rüstem Paşa Mosque	1562-1564	14,2	14,2	15,5	14,2	14,5	1,3
	Kadırga Sokullu Mehmet Paşa Mosque	1572	11	11,6	13	11,6	12,1	2
	Eski Valide Mosque	1570-9, 1583	9,7	10,6	13,5	10,6	11,3	3,8
	Sinan Paşa Mosque	1553-1556	7,4	11,3	13,5	11,3	10,8	6,1
	Nişancı Mehmet Paşa Mosque	1584-88	6,9	11,8	12,2	11,8	10,6	5,3
	Kara Ahmet Paşa Mosque	1554-1558	12,5	8,2	12,1	8,2	10,4	4,3
	Süleymaniye Mosque	1550-1557	5,2	12,9	10,3	12,9	10,3	7,7
	Şehzade Mosque	1543-1548	9,1	9,8	11	9,8	9,9	1,9
	Selimiye Mosque	1568-1574	8,7	10	9,2	10	9,4	1,3
	Molla Çelebi Mosque	1561-1562	7,4	9,1	8,6	9,1	8,5	1,7
	Üsküdar Mihrimah Sultan Mosque	1540-1548	7,5	8,2	8,9	6,9	7,9	1,4

4. CONCLUSION

In this review, which discusses fifteen mosques of Mimar Sinan with central plan schemes in Istanbul and Edirne, the contribution of the transparency ratios of the buildings to the central space is analyzed. In the first stage of the study, the general characteristics of the selected fifteen buildings of Mimar Sinan are examined through their plans, sections and façade drawings. Secondly, the approximate transparency ratios are calculated by proportioning the surface areas of the windows to the total façade area, in terms of the façade drawings of the buildings. Graphs (Figure 3) and tables (Tables 2-5) are made to analyze the contribution of these ratios to the central space.

If Tables 3 and 4, which show the transparency ratios of the selected mosques are examined, it is seen that each mosque has a different transparency ratio and these ratios vary according to the different façades of the buildings. When Figure 3, which graphically shows the change in the transparency ratios of the mosques, is examined, it is seen that there is no significant increase or decrease in the transparency ratios of the buildings due to chronology.

Considering Table 5, which ranks the buildings in the study according to their transparency ratios, it is seen that Edirnekapı Mihrimah Sultan Mosque has the highest transparency ratio and Üsküdar Mihrimah Sultan Mosque has the lowest transparency ratio according to all façades. On the north façade, Edirnekapı Mihrimah Sultan Mosque has the highest transparency rate and Süleymaniye Mosque has the lowest; on

the east and west façades, Zal Mahmut Paşa Mosque has the highest transparency rate and Üsküdar Mihrimah Sultan Mosque has the lowest; on the south façade, Edirnekapı Mihrimah Sultan Mosque has the highest transparency rate and Molla Çelebi Mosque has the lowest. When the change in transparency ratio between the façades is analyzed, it is observed that Kılıç Ali Paşa Mosque has the highest difference and Selimiye Mosque has the lowest, as shown in the table.

With the construction of six-pillar and eight-pillar mosques, the walls widely lost their role in supporting the central dome, and thus they allowed the opening of more windows on the façades. It is understood that Mimar Sinan's efforts to create the ideal unitary and collective space reached its climax with the Selimiye Mosque, considering the point that Classical Ottoman architecture had reached in terms of the structure system. Looking at the mosques he built in the following period, it is seen that variations of various schemes that existed before the Selimiye Mosque and its predecessors were used.

According to the hypothesis of the study, it is expected that the transparency rates of the buildings that contribute to the concept of central space will increase according to the architectural development. However, when the data obtained is examined, it is seen that the transparency ratios do not increase in parallel with the development of space and a direct relationship cannot be established between these ratios and the concept of central space.

When we examine the Şehzade, Süleymaniye and Selimiye Mosques, according to their transparency ratios and the difference between these ratios, Süleymaniye Mosque, Şehzade Mosque and Selimiye Mosque are ranked from high to low. It is seen that the Selimiye Mosque is one of the buildings with both the lowest transparency ratio and the smallest difference in transparency ratio between the façades. Accordingly, instead of obtaining the maximum number of façade openings with this building, he kept the openings on the façades close to equal and created a central space.

According to the results of the study, despite the subjective evaluations of the researchers, a direct relationship between the transparency ratio and the development of the central space in Mimar Sinan's mosques with a central plan scheme could not be determined. In particular, the eight-pillar Selimiye Mosque is known to be of great importance in terms of the development of the central space, although its transparency ratio was found to be lower than the others. This situation reveals that Sinan had different pursuits in the development of the central space and that the relationship between the transparency ratio and its contribution to the central space should be examined with different parameters.

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