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THE POINTED ARCH FORMATIONS AND COMPARATIVE ANALYSIS OF SÜLEYMANİYE MOSQUE, İSTANBUL

ABSTRACT

This study is an analytical review of arches as the key architectural elements in traditional structures especially pointed arches in Mimar Sinan's Süleymaniye Mosque in İstanbul. The question of how the pointed arches were designed and used in the classical period of the Ottoman architecture and the Sinan's Süleymaniye Mosque as the most important example of the period discussed in addition to many studies in which the arch that participates in structural fiction as part of the bearing system was examined within the scope of the style, several types of the arches that is a subspecies are mentioned depending on the position of the centers located by the division of span. On-site measurements were made for the arch formations, also restoration projects commissioned in 2007 by the Turkish Republic Directorate General of Foundations (VGM) and approved by the Cultural and Natural Heritage Conservation District Board of Turkish Minister of Culture and Tourism were used for the dimensions with permission. For the first time in our previous studies, research carried out on 19 mosques that were built in İstanbul during the period of Sinan. The question of which variables depends on the design of pointed arches according to their location and usage rates of arches formed by division of span were examined. Arches are also classified according to their locations; interior, narthex, court and facades. The categorical properties like preferred types, places of use and grouping features are discussed and considered together with quantities like span, height, centers of intrados for understanding geometric formation principles. Thus, new types were found like 1:7, 1:9, 1:11 beside known types like (1:5) penci arches and statistics like where and which conditions they were shown has been revealed. It has also been possible to compare buildings overused arch types that make up the form repertoires of the designer in selected works. The example of this extensive research detailed on a single building on Süleymaniye Mosque, best-known work of imperial architect Mimar Sinan. It has been revealed that pointed arches have been classified and arranged to provide speed and convenience in the design and construction process as a dominant stylistic determinant and founder of traditional construction systems.

Keywords: Süleymaniye Mosque, Mimar Sinan, Pointed Arch, Ottoman Architecture

1. INTRODUCTION

An arch is a curvilinear structure used to span a space (Sözen & Tanyeli, 1986) and defined as an arc-shaped piece of structure (Hasol, 1975) that its ends sit on these pillars or piers to cover an opening between two columns or two feet. The arch that is an important supporting element used in traditional construction systems has been developed in case that the size of the space to be span is bigger than the size of the parts the material, in other words, because of the necessity of spanning the large openings with small pieces (Batur, 1974; Kuban, 1973). As a curvilinear bearing element that basically works only when pressing and transfers the loads on it to the two end bearers, the main function of the arch is to empty the wall section underneath. It is also one of the important architectural elements that determine the architectural styles with arch form. For example, style ogival / arc en ogive / croiseed'ogive for gothic style is used in the same sense. While art history research focused on the form of the arch, a classification was often made on the intrados profile and similar features were mentioned for certain periods. The Ottomans moved architecture to an advanced point by developing the architectural elements and design principles that were used until its time and while, testing of new design methods has been possible with arch architecture in order to cover larger openings.

Ottoman architecture emerged with the use of most of the previously known arch forms and decoration techniques in new syntheses has used this element in a certain order and in a way that exhibits an

inclusive approach in the direction of its own preferences. It was seen that bricks, stone / brick alternatives and stone arches were used in the Ottoman period, starting from the early works. The use of bricks was made independent of the rubble wall masonry during the foundation years. Although there are opinions that it was used as decorative in Central Asia and India, the emergence of the pointed type is often associated with the Islamic world (Hill, 1993; Saoud, 2002). It was the criterion to foreground the bearing nature of the ogive. The reason for the use of a pointed arch to cover large openings is that this type of ogive gives less horizontal opening force. For the same reason, the semi-circular arch with large horizontal thrust was used in the places with secondary presets bearing less load. In addition to fulfilling the structural function of the arch in Ottoman architecture, its decorative use was also common thanks to the forms of the elements forming the arch or the side-by-side arrangement of more than one arch. In Ottoman architecture, arches were used to form a group by coming together indoors, in windows or porticos. Dimensions of the arches were made based on precise surveys produced with current technologies and on-site measurements. The data obtained at the end of the study were classified and compared with other structures also.



Figure 1 View of the Süleymaniye Mosque from Golden Horn

2. HISTORY of SÜLEYMANIYE COMPLEX, İSTANBUL

As the largest complex in the 16th century in the Süleymaniye district, which it has given its name, Süleymaniye is located at the most important point of the city skyline when viewed from the shores of Galata and Üsküdar, with its location on a sloping land towards the Golden Horn in Beyazıt - Edirnekapı axis (Kuban, 1994). A part of the Old Palace land was used for the construction of the complex and according to the inscription at the entrance door of the mosque, the construction of the building was started in H. 957/1550 and completed in 1557 (Barkan, 1972). After the construction of the mosque, which was built by Sultan Süleyman (1520-1560) for his late son Şehzade Mehmet, the construction of his own foundation, Süleymaniye Complex, started. The section covering the construction records of the Süleymaniye Complex, covering 1553-1557, was examined and published by Barkan; Relatively detailed information can be found in all Ottoman buildings, such as construction process, site organization, resources of building materials and construction techniques.

In the work titled *Tezkiretü'l Bünyan*, it is stated that after Sultan Süleyman decided to build Süleymaniye, he made the decision by talking to Sinan about the location and form of the building (Mülayim, 2010). In the same source, it is stated that Sultan Sinan was chosen as the worthiest person to open the mosque by Sultan Süleyman, and the key was given to him to open it (Sönmez, 1988). It is understood from the court provisions that materials were brought from many parts of the empire during the construction process, especially large stone blocks and marble columns belonging to ancient monuments known to exist. A special ship was built to transport large columns, marble from Marmara

Island, woodstone from İzmit and Yalova, lumber was brought from the Black Sea coast and from Biga region. Precious marble and colored stones were also bought from Sultan foundations like İznik Orhan Bey Madrasa. It is understood from the manuscripts that the use of the material belonging to the old buildings was of symbolic importance during this period (Kuran, 1986).

Süleymaniye Mosque was also damaged by earthquakes and fires, minarets and structures on the Golden Horn side of the complex were destroyed in 1660 fire. The complex, which was damaged in the 1766 earthquake, was repaired, and after the 1850 fire, the hospital had to be emptied. In 1869, the interior painting of the mosque was renewed, in 1913, the imaret section was established as a foundation museum, and later it was used as a museum of Turkish and Islamic Arts. The mosque and complex, which underwent major repairs in the 1930s and 1950s, have undergone a comprehensive restoration in recent years (Kuban, 1994).



Figure 2 Interior View of Süleymaniye Mosque (Reha Günay)

3. ARCHITECTURAL FEATURES OF THE BUILDING

The elements of the complex were built on terraces at different elevations due to the tendency of the area reserved for the building from the palace garden. When the level with mosques and tombs is considered essential, the primary school, the first- and second-degree madrasahs and the medical madrasah were arranged at the upper level with shops placed under them. Darüşşifa, imaret and tabhane were built at a lower level, with stables and caravanserai placed underneath them. The third- and fourth-degree madrasahs were not located at a single elevation due to the high slope of the land but were terraced within themselves. Darülhadis madrasa was built by filling the land with the help of a retaining wall (Cantay, 1988). The layout of the complex shows a successful harmony with the topography, while the mosque structure in the center is evident, it is not easy to realize the dimensions of the complex of structures spread over a wide area as the other units integrate with the texture it is in (Aslanapa, 2004).

3.1. Establishment of the Structure (Interior)

After the success of Mimar Sinan with Şehzade Mehmet Mosque in the design of the central dome, the Süleymaniye Mosque which was built by supporting the main dome with half domes in two directions, creates an uninterrupted perception of volume compared to similar Hagia Sophia in terms of interior integrity. 2 half domes, which are added to the main dome on the qibla axis, sit on the main piers inside and the buttresses on the body walls in the north and south directions. While these buttresses are sticking out on the Qibla wall, they are taken inside at the north wall of the mosque and form upper-floor partitions inside them. The buttresses located on the eastern and western facades of the mosque constitute the side lodges inside and the semi-open sofas outside.

The high portico arrangement formed by three large pointed arches between the piers carrying the main dome (east and west) strengthens the participation of the side aisles in the nave, prayer hall or harim

space. This triple arch arrangement repeats on the side facade behind the columns and carries a three-domed roof in the east-west direction of the mosque and the corner spaces are also covered with a dome. The four large stone piers were chamfered to make them look thinner and niches were opened on their surfaces. The openings between the monumental piers in the interior are 21,60 m in the north-south direction and 23,00 m in the east-west direction, and the distances between body walls and piers are 7,80 m in the north and south directions and 6,70 m on the side facades. The height of the main dome keystone from the ground is 48,10 m, and the initial level is 33,60 m. The starting levels of the large arches are 18,30 m from the ground and the keystone heights are 30,80 m.



Figure 3 Interior View of East Side, Süleymaniye Mosque (Reha Günay)

The fact that two of the large arches carrying the main dome with a diameter of 27,40 m can be perceived from outside (eastern and western tympanums that provide light inside) in the direction of the Golden Horn and Marmara, also contributes positively to the harmony of the mosque's external appearance with the topography. The silhouette of the building gains movement with the use of domes of different sizes and weight towers on the side facades. Instead of the central plan supported by the four semi-domes that he applied just before Süleymaniye, this formation reflects his opinion regarding the location of the building on a stretched ridge (Kuban, 1994). The upper floor lodges located in the middle of the east and west facades of the interior are located in wall niches between the buttresses extending from the walls. These lodges, with a height of approximately 5,00 m above the ground, lean on two large columns bearing the top cover of the side aisles and sit with pointed arches to the columns placed between them. The galleries on the north wall of the interior are between the wall buttresses on both sides of the main entrance door and are carried by two columns. The ground level is raised two steps above the harim floor under these side and rear sections.

3.2. Building Facades

Since the load-bearing functions of the walls are minimized, they are easily emptied, and their surfaces are provided with a bright interior with hundreds of windows. The covering properties of the walls have been reduced except the south (qibla/mihrab) wall, and they rise to approximately one-third of the building. The drums of the domes also illuminate the prayer hall with windows. The two-floor semi-open arcade arrangement (side galleries) we see on the side facades is the more developed form of the system Sinan has previously applied in Şehzade Mehmet Mosque, and the mosque has secondary entrances at both ends of the arrangement. These sections between the buttresses are covered with a hipped roof. On the second floor, the arch sequence consists of pointed arches of similar size which sit on 17 columns, and on the lower floor, it differs by a symmetrical arrangement of 5 large and 2 small arches. The entrance spaces on the side facades are arranged in the form of a three-arched portico bounded by the minaret base in the north and the corner buttress in the south. The top of the entrance is

covered by three domes, the larger on the arch that reveals the door in the middle, also arches are likewise arranged by the symmetrical placement of large and small types.

3.3. Courtyard and Narthex

The courtyard is surrounded by porches covered with twenty-eight domes, nine in the direction of the mosque and seven on the sides. Courtyard domes that placed on the pendentives are higher in the narthex place. Different colors are noticeable in the materials used in the wide courtyard, the columns are white marble and red porphyry and the floor is white marble. The walls surrounding the courtyard were opened with double rows of windows, rectangular at the bottom and pointed arches at the top. The minarets on the corners where the courtyard meets the mosque are three balconies and higher (76,00 m), while the minarets rising in the northwestern corners are two balconies and lower (56,00 m).



Figure 4 North Elevation View of Mosque From Courtyard (Reha Günay)

According to Kuban, Sinan made a successful addition to the İstanbul skyline with the formation of overall mass effect, while the side galleries application he previously tried in the Şehzade Mehmet Mosque were eased, and he went to a multi-storey arrangement that was encountered for the first time at the north gate of the courtyard (Kuban, 2007). This three-storey arrangement, reminiscent of the monumental entrances seen in the Mamluk madrasahs, was arranged as official rooms in Süleymaniye but was not continued after this application. Again, it is one of the innovations that Sinan brought with this work, that the need for the fountain was solved on the lower floor of these galleries instead of the courtyard.



Figure 5 View From East Elevation of Süleymaniye Mosque (İnci Türkoğlu)

4. TYPES AND SPECS OF ARCHES USED IN SÜLEYMANİYE MOSQUE

In this study, since the foundation principles of the arches in the Süleymaniye Mosque are examined, locations of these arches in the structural system should be defined first. The arches are divided into 3 groups, primarily those in the interior, those in the courtyard and narthex place, those seen on the facades. Coded arches can be seen on the plans and all size properties can be seen from the tables.

4.1. Parameters That Determine the Shape of An Arch

The main features we use to classify the arches we examine are the opening (span) and the location of the centers of the curves. The history and diversity of the arch types and the problem of their origin that we have presented in our previous publications will not be covered in this study (Özyalvaç, 2013). The arch types that we encounter in this building and used extensively during the period we will make comparisons are rounded arches, two-centered pointed arches and limited to several versions of these types. For this reason, the way of handling the arches as mathematical objects and determining the principles of geometrical establishment is followed. As can be seen in the conclusion, classical period Ottoman architecture preferred to be content with a small number of types even in this greatest work and reduced the variety to provide unity. In the tables showing 14 different values for each of the arch types we encounter in this structure, 43 different arches in total (20 in the interior, 12 in the courtyard and the narthex place and 11 on the facades) were identified and documented. The names of the arches are shown on the plan, and a meaningful sample was chosen from among those repeated since the structure is symmetrical on the qibla axis and the repeating structure of the portico sections, the arch types examined can be reduced to a few types.

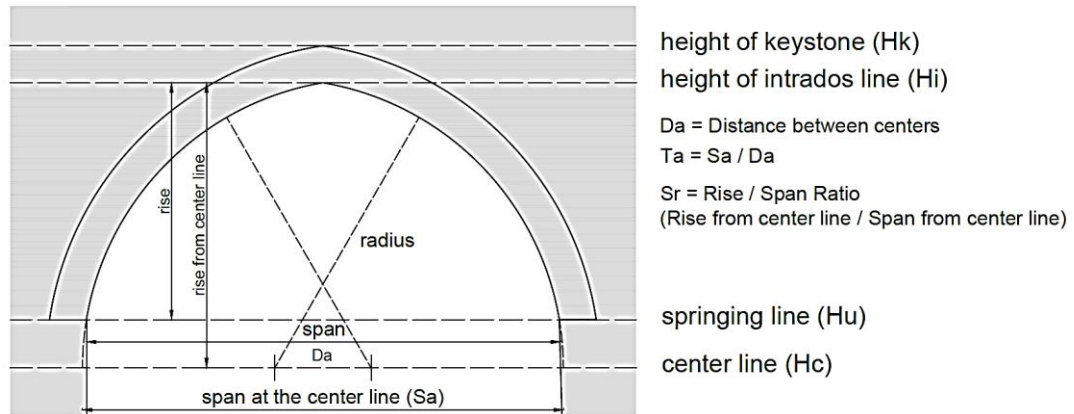


Figure 6 Definition About Parts of Pointed Arches and Abbreviations

The properties that define the arches are as follows; the span of the arch (**Sa**), the distance between centers of the curves (**Da**), the ratio between (**Sa**) and (**Da**) (frequently named arches with this value, (**Ta**) type of arch), the height of intrados from the centerline or rise of the arch (**Ha**), the ratio between (**Sa**) and (**Ha**) also called “rise / span ratio” (**Sr**) and used as a determine the type, the height of these points from the ground where the arch is located (**Hk**, **Hi**, **Hu**, **Hc**), the depth of the arch in plan (**Ga**) and the thickness of the arch seen on the facade -distance between intrados and extrados- (**Ka**) and radius of intrados arc (**Ar**), (Figure 5).

4.2. Locations of Selected Arches in the Building

The arches [A1] and [A2], connecting the four great piers and carrying the central dome, have the largest span and begin at the springing level of 19,30 m, (Figure 7 and 8). The porticoes, separating the nave from side aisles in the east and west, sit on the columns and piers with two small [A3] and one large [A4] pointed arch in the middle. The springing level of these arches is 10,70 m and the elevation of the highest point is 17,10 m. Pointed arches that connect these columns to the wall direction are defined as [A5]. Pointed arches [A6], which connect large piers to the mihrab wall, are also repeated in the north of the prayer hall. These arches consist of two identical arches with 1,50 m distance.

The pointed arches that connect the buttresses embedded on the mihrab wall are [A7] and [A9]. Arches [A8] are located on the upper floor galleries on both sides of the entrance door on the north wall. The

arches [A10] and [A11] connect the buttresses embedded on side body walls at the springing level of 10,70 m on the east and west facades of the interior. [A12], [A13], [A14] and [A15] pointed arches with a springing level of 3,02 m are located on the columns bearing upper floor galleries in the east and west of side aisles (Figure 10). [A16] is on the side entrance doors. The pointed arch [A17] is under the sultan’s lodge at the east corner of the mihrab wall. The [A18] arch on the columns supporting the upper floor galleries on both sides of the entrance door in the north direction, and one large [A19] and two small [A20] pointed arches in the middle on the gallery above the entrance door (Figure 9).

In the narthex section of the mosque integrated with the courtyard, the columns are connected to each other by a large one [B1] at the entrance gate axis, and three with smaller span pointed arches [B2] at the sides (Figure 11). On the north side of the courtyard, the springing level of the three arches has been raised in the middle, which indicates the entrance, and the middle arch is [B5], the ones on the sides [B3] and [B4] (Figure 12). The arches connected the walls surrounding the courtyard to the columns in the north and south directions are [B9] and in the east and west directions are [B8]. On the columns facing the courtyard, there is one large [B7] in the middle and two small [B6] pointed arches on the sides (Figure 13). [B10] and [B11] are relieving arches on the windows with rectangular openings on the walls surrounding the courtyard. [B12] is located on the north gate of the courtyard and its springing line is at 5,47 m height.

The arrangement of a two-storey semi-open gallery on the west side of the mosque and the arches in the entrance porticoes were examined, 11 different types and sizes were identified (Figure 14). There are 16 arches on 17 columns on the upper floor of the two-storey gallery, and the pointed arches are arranged from the center to the ends as b-b-a-c-a-b-b-a. The pointed arches in the middle are [C1], and the [C3] and [C2] arches located next to it. On the ground floor, a symmetrical arrangement with 4 different types can be seen in the composition consisting of 9 arches on 10 columns. There are pointed arches [C5] in the center, [C6] and [C7] arches on both sides. The two arches at the end are defined as [C4]. The portico in front of the western entrance gate adjacent to the minaret is arranged with one large [C11] in the middle and two small [C10] pointed arches on the sides. On the southern end of the facade, in front of the entrance, there are three pointed arches of similar size, [C8] in the middle and [C9] on the sides.

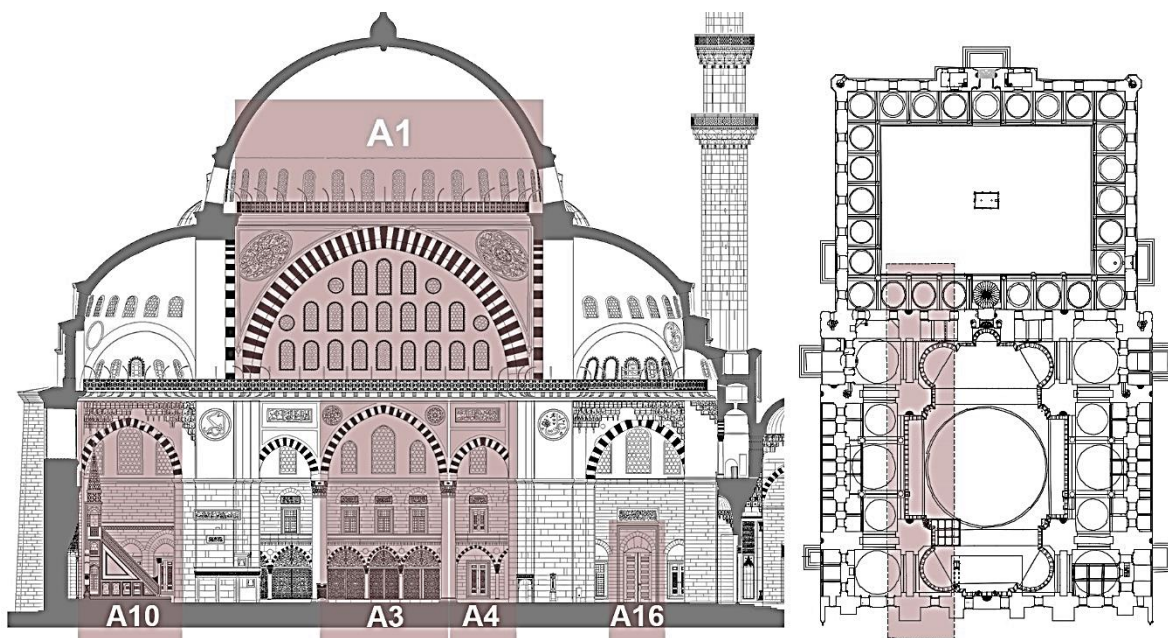


Figure 7 Ach Locations at Section (Edited Drawing of VGM Archive)

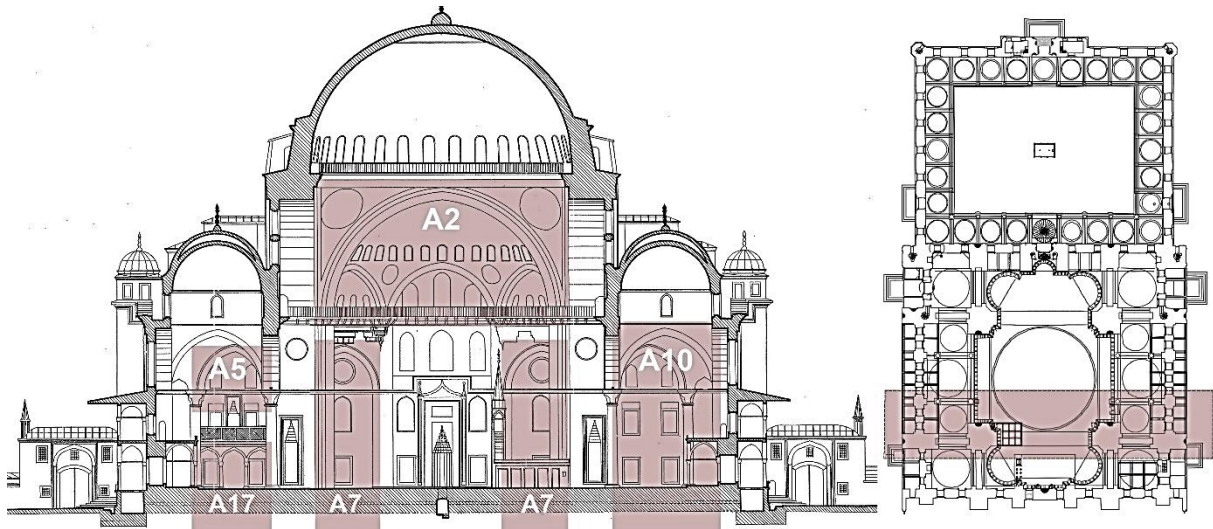


Figure 8 Arch Locations at Section (Edited Drawing of A.S. Ülgen)

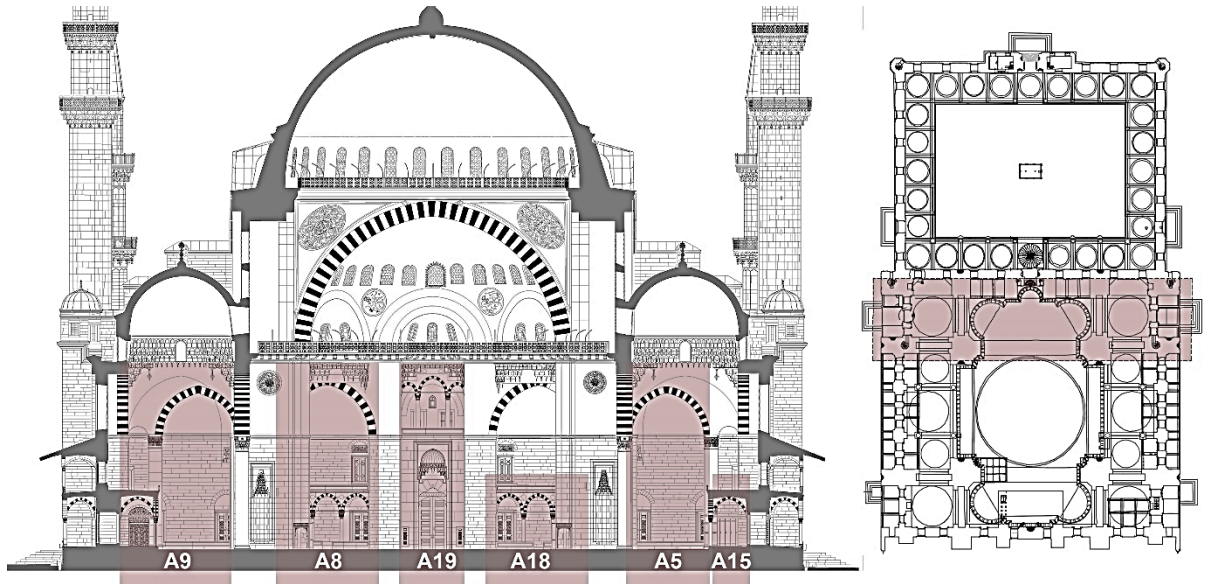


Figure 9 Arch Locations at North Wall of Interior (Edited Drawing of VGM Archive)

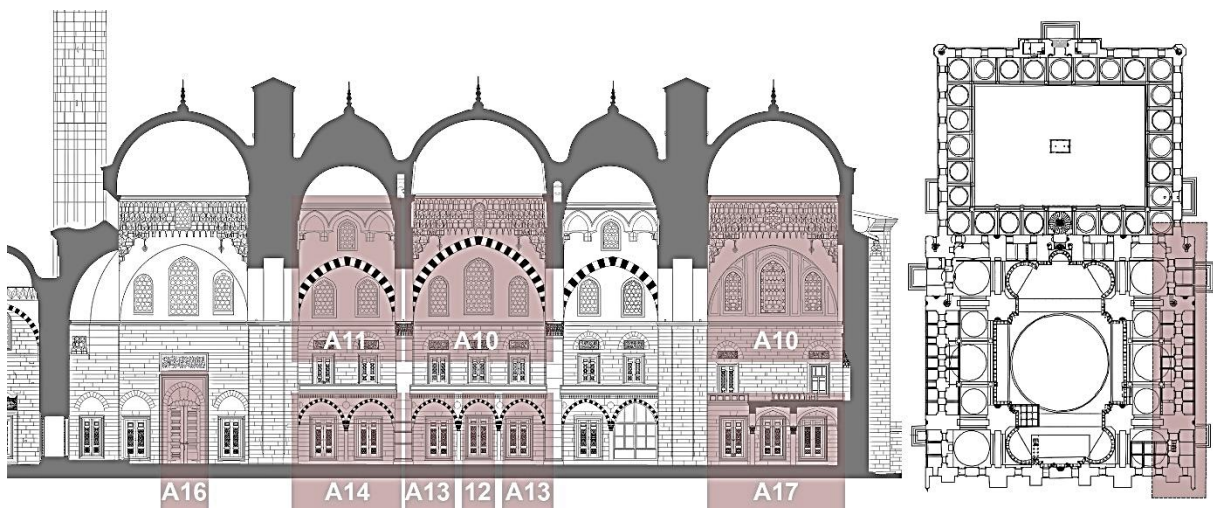


Figure 10 Arch Locations at East Wall of Interior (Edited Drawing of VGM Archive)

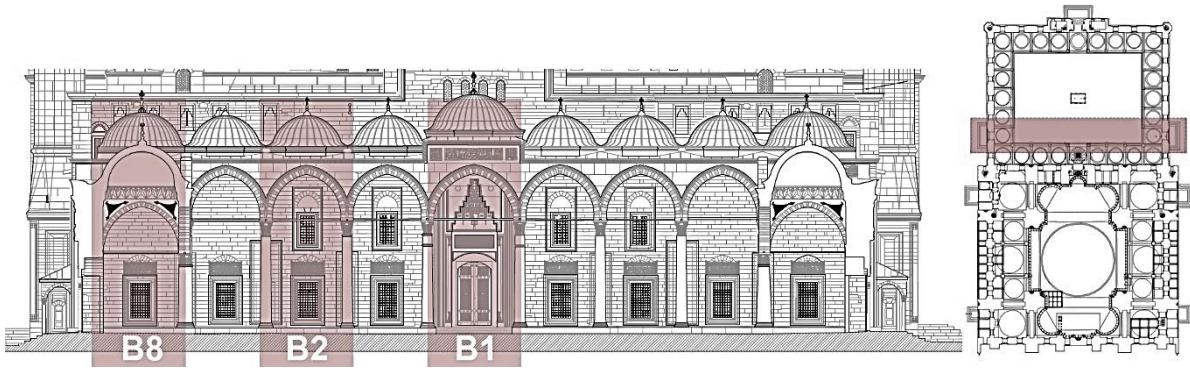


Figure 11 Arch Locations at North Elevation – Narthex Facade (Edited Drawings of VGM Archive)

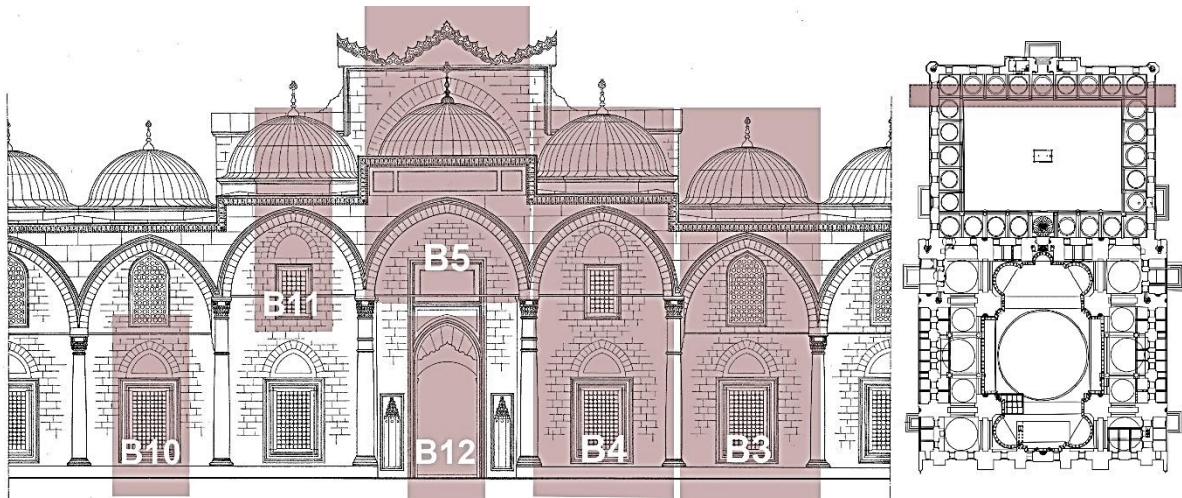


Figure 12 Arch Locations at the View to the North From Courtyard (Edited Drawing of A.S. Ülgen)

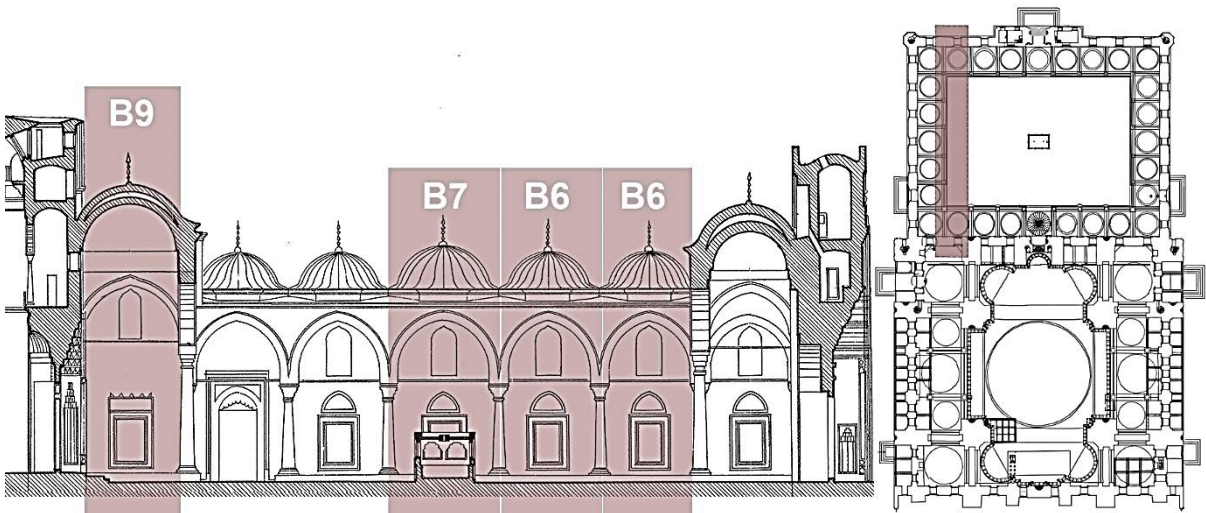


Figure 13 Arch Locations at the View to the West From Courtyard (Edited Drawing of A.S. Ülgen)

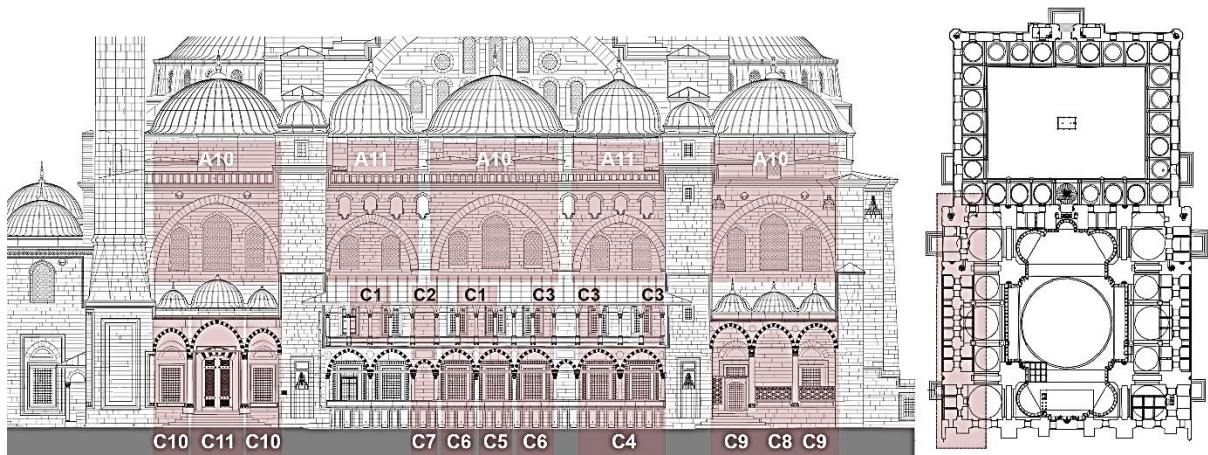


Figure 14 Arch Locations at West Elevation (Edited Drawings of VGM Archive)

5. EVALUATION OF DIMENSION PROPERTIES AND COMPARISON WITH OTHER SİNAN MOSQUES IN İSTANBUL

43 different arches were found in the Süleymaniye Mosque; 20 interiors, 12 in the courtyard and narthex and 11 on the facades. The arches examined are collected in 8 types according to the (**Ta**) span / distance between centers ratio: (1: 3), (1: 4), (1:5), (1: 5,5), (1: 6), (1: 7) and (1:11) are pointed arches and only one of the types is (1:5T) with flat topping. It is noteworthy that the pointed arch with (1:5) (**Ta**) ratio was mostly used in the building. The single type outside of the two-center pointed arches was found only in two places: on the columns bearing the sultan's interior in the interior and on the façades of the galleries in the east and west directions. Except for the two-center pointed arches, the single type was found only in two places: on the columns bearing the sultan's lodge in the interior and on the facades of the east and west galleries. The (1:11) (**Ta**) ratio arches carrying the dome with a span of 23,25 m and 21,59 m were the largest and highest arches among Sinan's 19 important mosques in İstanbul.

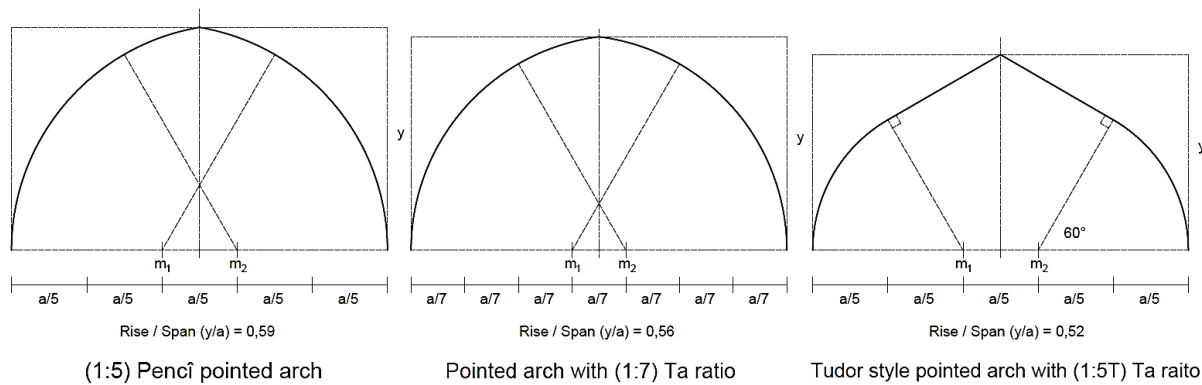


Figure 15 Pointed Arch Samples Found in Süleymaniye Mosque and Drawing Method by Dividing the Span

The 9.70 m span arches on the facades of the domed corner units are also among the top 10 in 19 mosques and more than 300 arches examined. Apart from the (1:11) (**Ta**) ratio pointed arches carrying the dome in the interior, only 2 of the 20 types are different from penci type (1:5) pointed arch, and they have a (**Ta**) ratio of (1:6) and (1:7). Pointed arches with a (**Ta**) ratio of (1:6) are used on the entrance gates in the east and west directions of the mosque, while pointed arches with a (**Ta**) ratio of (1:7) were used between the columns separating the side aisles from the nave and the walls in the east and west directions. Apart from these few types, the (1:5) penci type pointed arches used between the columns and facades dominate the appearance of the interiors, and this state of domination continues in the courtyard. 5 of the 7 pointed arches used in the courtyard are (1:5) (**Ta**) ratio penci arches, the other two are the arches on the northern entrance of the courtyard (1:5,5) to specify entry and in the middle of the east and west facades (1:7) to identify the central axle. Also, a two-center pointed arch was found with a (**Ta**) ratio of (1:4) above the entering on north facade, on the walls surrounding the courtyard. The entrance porches, located at the north ends of the east and west facades of the mosque, is arranged with

one large and in the middle and smalls on both sides with (1:5) pointed arches. Likewise, all 4 different arch types used on the ground floor of the two-storey outer side galleries are pointed arches with a (Ta) ratio of (1:5). On the upper floor of the outer side galleries, two-center pointed arches with (1:3) (Ta) ratio and (1:5T) ratio Tudor style penci arches are found on the columns bearing the roof.

6. RESULTS

Considering the enormous dimensions and sophisticated design features of the Süleymaniye Mosque, it is noteworthy that it was built with the use of so few types. For comparison, more types were found in smaller buildings such as Azapkapı Sokullu Mehmet Paşa Mosque (11) or Zal Mahmut Paşa Mosques (11) than those used in the Süleymaniye Mosque. However, the limited number of arch types used in Şehzade Mehmet (7) or Üsküdar Mihrimah Sultan Mosques (7) suggests that there may be a conscious tendency to design important and large structures with fewer arch types, so it can be said that this feature is accepted as a criterion of success in design. For other examples, we can refer to our previous publications (Özyalvaç & Özyalvaç, 2017). The two examples of large pointed arches with (1:11) ratio under the dome in the same location in other buildings are the mosques of Üsküdar Mihrimah Sultan and Eyüp Zal Mahmut Paşa. Pointed arches fastening piers embedded in the body walls in Süleymaniye Mosque are two center pointed arches with (1:5) ratio, and it is known that they used in the same place in 5 more mosques Sinan made: Şehzade Mehmet, Üsküdar Atik Valide, Azapkapı Sokullu Mehmet Paşa, Fatih Nişancı Mehmet Paşa and Üsküdar Mihrimah Sultan. Following this most preferred type of arch, (1:11) and (1:9) (Ta) ratio pointed arches were used in this position. The fact that these arches are dominant in the general view of interior thus should be effective in this selection. As in most of the other Sinan mosques, penci arch with (1:5) ratio also used in the relieving arches above the rectangular windows on the ground floor. In the porticos of the narthex place of the mosques, the arch type we see here (1:5) also preferred more than the other common types like (1:9) and (1:7) ratio pointed arches, also several types can be seen together in the courtyard of some buildings.

Consequently, considering all arch selections, the Süleymaniye Mosque is located at the intersection set of these preferences in the classical period Ottoman mosque architecture, success has been built on unity in diversity. Undoubtedly, this union brought convenience and speed in production as well as integrity in style.

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Table 1 Pointed arch specifications used in Süleymaniye Mosque (Interior) (dimensions in cm)

	A.01	A.02	A.03	A.04	A.05	A.06	A.07	A.08	A.09	A.10
Sa	2159	2325	969	450	670	787	680	772	970	970
Ha	1170	1264	571	266	376	465	400	460	570	570
Hk	1360	1377	639	331	465	531	463	532	*	633
Sr	0,54	0,54	0,59	0,59	0,56	0,59	0,59	0,59	0,59	0,59
Ar	1175	1268	580	270	382	472	409	463	582	582
Da	196	211	193	90	96	158	136	154	194	194
Ta	11	11	5	5	7	5	5	5	5	5
Hu	1930	1930	1071	1071	1070	1072	1072	1070	1070	1070
Hc	1903	1883	1071	1096	1070	1072	1072	1070	1070	1070
Ka	188	110	68	68	63	68	59	73	*	64
Ga	110	80	155	155	138	111	75	440	*	186
Hi	3073	3147	1642	1362	1446	1537	1472	1530	1638	1640
Hk	3260	3260	1710	1427	1536	1603	1535	1602	*	1703

	A.11	A.12	A.13	A.14	A.15	A.16	A.17	A.18	A.19	A.20
Sa	700	251	313	330	296	244	256	219	226	122
Ha	411	146	186	195	175	141	120	129	133	72
Hk	480	189	209	218	200	179	136	150	159	99
Sr	0,59	0,59	0,59	0,59	0,59	0,57	0,47	0,59	0,59	0,59
Ar	420	150	188	198	178	142	102	131	135	73
Da	140	50	62	66	59	41	52	44	45	24
Ta	5	5	5	5	5	6	5T	5	5	5
Hu	1070	302	302	302	302	452	291	346	1461	1461
Hc	1070	317	283	273	292	440	291	373	1461	1461
Ka	64	23	23	21	23	38	21	27	25	25
Ga	186	47	47	47	47	46	52	53	55	55
Hi	1481	463	469	468	467	581	411	502	1592	1532
Hk	1550	491	492	491	492	619	427	523	1620	1560

Table 2 Pointed Arch Specifications Used in Süleymaniye Mosque (Courtyard) (Dimensions in cm)

	B.01	B.02	B.03	B.04	B.05	B.06	B.07	B.08	B.09	B.10	B.11	B.12
Sa	620	530	538	547	615	538	595	580	590	214	244	272
Ha	367	315	318	320	357	320	334	345	350	127	144	167
Hk	410	367	388	349	396	388	408	408	404	167	182	217
Sr	0,59	0,59	0,59	0,59	0,58	0,59	0,56	0,59	0,59	0,59	0,59	0,61
Ar	372	318	323	328	361	323	340	348	354	128	146	172
Da	124	106	107	110	112	107	85	115	118	43	49	69
Ta	5	5	5	5	5,5	5	7	5	5	5	5	4
Hu	880	880	621	621	797	620	620	620	878	464	464	547
Hc	880	923	635	642	797	635	620	640	878	451	464	508
Ka	45	43	40	36	32	39	39	39	46	40	38	40
Ga	103	103	88	88	89	88	88	88	102	*	*	*
Hi	1247	1238	993	987	1154	993	954	985	1228	578	608	675
Hk	1290	1290	1030	1141	1191	1028	1028	1018	1282	618	646	725

Table 3 Pointed Arch Specifications Used in Süleymaniye Mosque (Facades) (Dimensions in cm)

	C.01	C.02	C.03	C.04	C.05	C.06	C.07	C.08	C.09	C.10	C.11
Sa	120	150	141	296	253	275	130	285	275	377	240
Ha	77	77	83	175	149	162	77	168	163	222	141
Hk	97	97	103	186	163	179	100	198	189	251	171
Sr	0,64	0,51	0,59	0,59	0,59	0,59	0,59	0,59	0,59	0,59	0,59
Ar	80	60	84	177	150	165	78	171	165	226	144
Da	40	30	28	59	50	55	26	57	56	75	48
Ta	3	5T	5	5	5	5	5	5	5	5	5
Hu	258	258	258	289	289	289	289	512	512	488	488
Hc	258	258	252	277	300	284	301	512	512	488	503
Ka	19	19	19	24	24	24	24	28	28	27	27
Ga	45	45	45	45	45	45	45	55	55	55	55
Hi	335	335	335	463	463	463	367	680	675	710	644
Hk	355	355	355	475	475	475	390	704	701	739	674

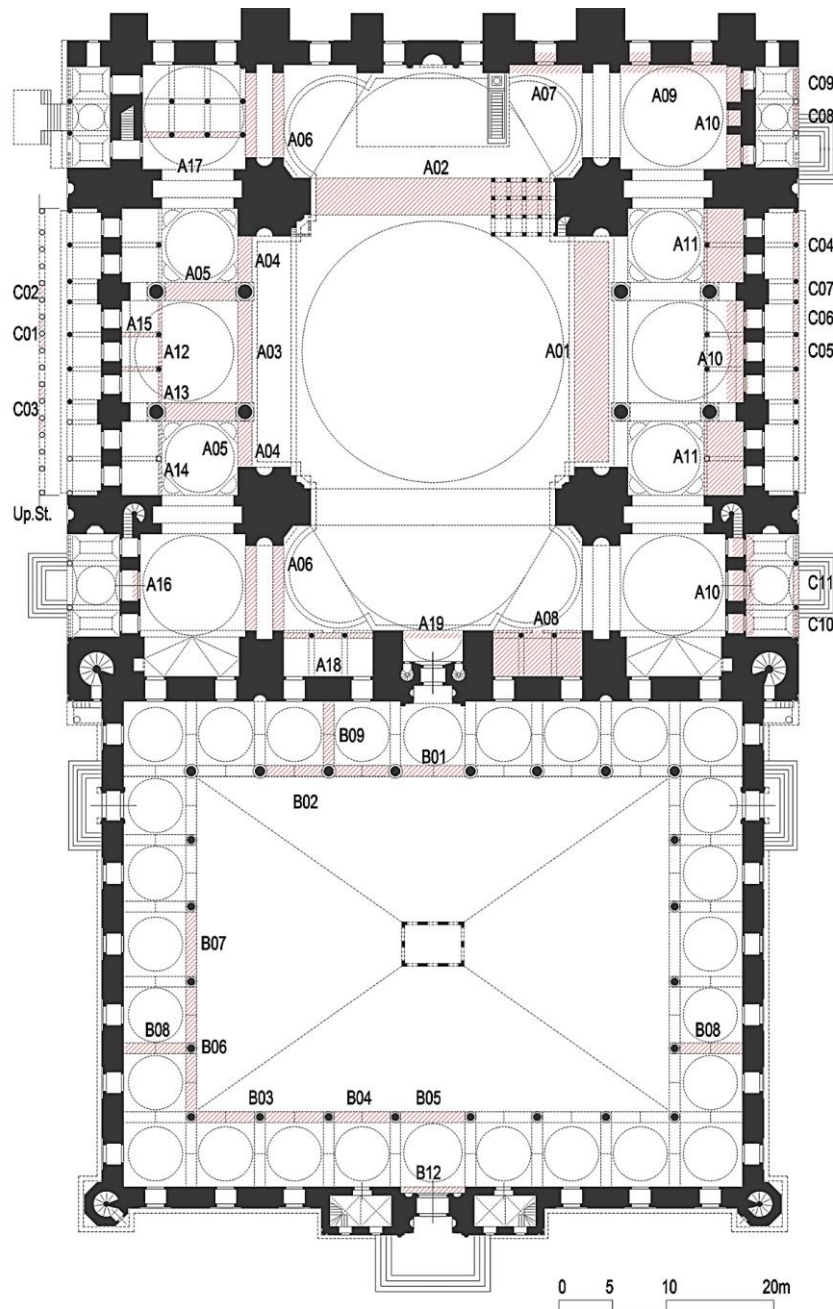


Figure 16 Examined Arches on Ground Floor Plan of Süleymaniye Mosque (Edited Drawing of Necipoğlu)