

Suleymaniye Mosque of Mimar Sinan in Turkish Architectural Construction History

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ABSTRACT: The most distinguished and the greatest architect of the Ottoman Empire and also of the Turkish Architecture is Mimar Sinan. He had built lots of mosques, bridges and complexes, mainly in Istanbul and in the sovereignty of the Ottoman Empire. One of his most famous mosques is Suleymaniye, built for Sultan Suleyman in 16th century. The structural solution of the whole building will be explained in terms of the load transferring structure, starting from the top of the dome to the end of the columns and the perimeter masonry walls, supported with iron bars in between the columns at the end points of the arches, spanning the upper space above the people. The main characteristics of the mosque are the main full dome, supported with two half domes from two sides, while for the other sides there are walls under arches. Also there are small load balancing towers built around the sphere of the bottom layer of the dome. The retaining walls supporting the arches are lowering down by decreasing step by step. And iron bars, connecting the ends of arches can be seen in everywhere, both inside and outside. In this paper, all of these will be defined in a more detailed manner by showing the achievements of the construction technology in the Ottoman Empire Period in the 16th century.

INTRODUCTION

Introduction of the National Research Project for TUBITAK

All the authors, are participants of Cost Action C25 Sustainability of Constructions: Integrated Approach to Lifetime Structural Engineering, as the Turkish Team, supported by the European Union. Then in the name of Turkey, its representative Yesim Kamile Aktuglu, TUBITAK– Turkiye Bilimsel ve Teknolojik Arastırma Kurumu, the Scientific and Technological Research Council of Turkey, signed the agreement, when the authors accepted to prepare a National Research Project, numbered and named as, "107M627: Korunmus Sehir Dokusunun Karakteristiklerinin Surdurulebilirliđi Baglamında, Ozellikle Bassehirlerdeki Eski Binalarin Yapiminin Irdelenmesi Sonucu, O Bölgeledeki Yeni Yapiacak Binalar İcin, Uyulmasi Gerekli, Hem Tasarimsal ve Hem de Yapisal Nitelikteki Kriterlerin Belirlenmesi", parallel to the subject of the Cost Research Project. The authors divided their National Research project into three periods. In the first 8 months, they would research about 7 mosques built by Mimar Sinan. In TUBITAK Project, the authors all shared the mosques of Mimar Sinan, to observe them altogether, named as Suleymaniye Camii, Selimiye Camii, Şehzade Camii, Mihrimah Sultan Camii Edirnekapi, Mihrimah Sultan Camii Uskudar, Kilic Ali Camii, Sokollu Camii. Only Selimiye Camii is in Edirne, the others are in Istanbul. They are conducting their researches to define why all these mosques, for a long period around 450 years, are still standing in the manner of sustainability with their construction level. And while discussing about a mosque, the authors compared its structural solution with other mosques' structural systems. 6 of the authors, altogether went to Istanbul and Edirne to visit the mosques once more, and to discuss about them at their places on 6-8 June 2008. This visit also helped to see the details once more. And during the discussions, they had easily defined the place of details, and understood the invisible sections of the details. Therefore, most of the paper is written due to investigations in June 2008.

Introduction of Suleymaniye Camii

All around the world, there are lots of mosques for Muslim Religion. When researched about the structural solutions and construction details of these mosques, it can be easily seen that nearly all of them are having very simple patterns, including a simple dome above, and very common roof solutions. Perhaps, Aya Sofya was the starting step for designing the mosques under one full dome ,together with other semi domes and small

domes, supporting the main structure of the building. In this paper, while defining the construction history of Suleymaniye Mosque, through the other mosques of Mimar Sinan, the authors might emphasize that Suleymaniye Mosque is really a world wonder and a landmark not only for religious buildings, but also for large buildings for all people. Besides, the dimensions of the mosque and the features of its structural solution, create a unique atmosphere inside, with its main dome 48 mt. from the ground level inside. Nearly for all mosques, the minarets are also additional structural towers to balance the loads by transferring them from the top point of the main dome to the earth level. Sometimes, here in this case, they connect the structure of the semi covered spaces surrounding the garden, named "avlu", with the fountains in the middle to make the people clean in a specific way, which is named "abdest", easily in a short time before praying. In summer time, when the mosque is full with people, the rest can do their prays with movements, named "namaz", also in avlu. While all other mosques of Sinan have different patterns to use the dome and semi domes, here in Suleymaniye Camii, the authors plan to do observations about the composition of a main dome and two half domes supporting the main dome.

STRUCTURE AND CONSTRUCTION DETAILS OF SULEYMANIYE MOSQUE

In all mosques of Mimar Sinan, dome and semi domes are the main structural figures together with arches. And to sustain the huge masonry walls, there are restraint walls to support the long and high masonry walls of the "mihrab" wall towards Kâbe in Mekke. All stones, mainly in the perimeter wall of the "avlu", are cut elegantly to fit with the other stones, and connected with iron flat pieces by flooding lead to make the connection of the two iron flat pieces inside the stone blocks to make them strong enough against earthquake movements. This detail is very important for Turkey, where 95% of its lands are in earthquake region, including Istanbul in the first danger zone.

In plan layout

Mainly the layout of domes covering the roof is organizing the plan layout to gather people and to provide them a convenient worship place in a unique and one space.

In the site plan of Suleymaniye Mosque, according to the architectural ground plan in Gunay's book, the main covered "mosque space" has a plan with around 67m*61 m(66.07m* 60.7m) from the main entrance wall to the main praying wall, including all framing walls outside. The inner space just below the main dome and surrounding arches to carry the loads coming from the main dome and semi domes in the both sides along the entrance axis, is around 22.3m*22.3m with a height of 48m that its height was measured by the team on June 7, 2008, till to top point of the dome from inside. When the spaces of two semi domes are added, a dimension around 51.8m is reached at first as a unique clean space to gather all people under one dome, supported with two semi domes. At the right and left wings of the main dome, there are huge walls under the arches supporting the main dome, with 19 large rectangular windows and 4 small circular windows on them. Also, these walls are being supported with a group of domes consisting of one big dome and two small domes at both sides.

And also the semi domes are being supported with smaller semi domes. Finally four domes, one at each of the corners of the plan of the mosque, behave as the stop points of the transferring loads from the top of the main dome to the corners of the plan, then through the masonry walls to the earth.

Finally at the right and left sides of the entrance there are galleries in two stories to empty the thick masonry wall framed with iron bars to strengthen the whole structure to carry the mosque's load.

In the garden, named "avlu", there are columns to carry the loads coming from the domes to cover the spaces around the garden as semi covered spaces, and there is a perimeter wall to get the loads coming from the domes and to cover the garden area. In the intersection wall of the garden and mosque, there is stepping in the layout of the domes again in the name of carrying the loads while presenting the entrance of the mosque.



Figure 1 (left): View of Suleymaniye Camii from Eminonu; (photo by Yesim Kamile Aktuglu, on 7th of June 2008)

Figure 2 (right): View of Mihrab Wall from outside; (photo by Yesim Kamile Aktuglu, on 7th of June 2008)

In section layout

In the small domes at the right and left sides of the entrance axis, there is double dome structure. The inner one is having normal angle to pass the space. The outer dome structure is constructed by Ottoman bricks which are 3-4cm at height, while they are around 10cm*20cm in dimension with x-y coordinates to have a more inclined surface to be seen from far away. The inclined surface is having a shape as an angle with 90 degrees at the top point of the dome, means loads are transferring in the most suitable form.

In the main dome, since the starting date of our research, the team was hoping to have a double dome construction again. For there are lots of iron bars, or iron ropes coming out from the lower level of the dome construction which is 48 m high from the ground level, it's suggested that first there should be an iron cage to carry all these, and then there should be a second cover to make the dome be seen very easily from far away by having steeper angle. Finally when the team reached to the top with an elevator during the restoration in June 2008, they took lots of photos, to be able to arrange a realistic discussion platform. And also from the inside of the coverage of the hole, to make the iron rope hang to carry the biggest lightening, the team took several photos. Then when the photos were examined several times, it's recognized that the starting point of the iron cage with a circle first, then the iron plates in radial position towards the end corners of the whole structure, with bricks between the iron plates. While these iron plates go down, the supporting structural elements of the balcony - the iron bars catch the iron plates under the plaster to be welded. This is a very common solution as Brunelleschi did use it the very first time in Santa Maria del Fiore in Florence.

Also in a book named Tersale, it is drawn that there is an underground tunnel under the mid point of the mosque space to the fountains' water storage in the courtyard. The team saw the entrance of this underground tunnel, but never tried to enter. There is a nice question mark for the *raison d'être* of this tunnel, connecting inside and the outside from the mid point of Mosque.

When the team saw some broken painting over the arches, that maybe the water follows an easy way through the light structure of the arches. Also there are similar broken paintings in other mosques of Sinan the team researched.

In view layout

When Suleymaniye Mosque is looked at from four sides, it can easily be seen that the whole view as an angle with its 90 degree at the top, and the outer lines are following the edges of triangle with 45 degrees at the ends. This means loads are being transferred to the earth through the general load transferring pattern.

Also with dome figures and the vertical facades with window openings, the mosque is having a perfect balance through symmetry, according to the main entrance axis, with solid and transparent parts of the construction.

The most important subject about the mosques built in Istanbul during the Ottoman Empire period, they have to be seen from far away. For finally all mosques were named after the Ottoman Sultans or very important administrators. Then the mosques really have to be recognized very easily from the built environment.

While passing over the Halic towards Suleymaniye Complex, the mosque at the highest level is Suleymaniye Mosque, even though there are several important mosques in the view.

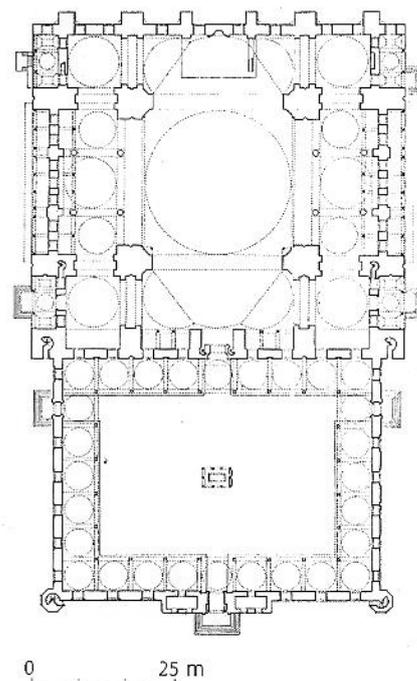


Figure 3 (left): View of right side wall according to the main entrance axis, with columns connected with iron bars; (photo by Yesim Kamile Aktuglu on 7th of June 2008)

Figure 4 (right): The plan of Suleymaniye Mosque; (Gunay, R. p.60)

In total layout

In fact, Suleymaniye Camii is at the heart of Suleymaniye Complex, composed by food courts, hospitals, schools, hotels, baths and shopping spaces as a pattern for all Ottoman Kulliye. Additionally the grave of Mimar Sinan is at the corner across the street just near the garden of Suleymaniye Camii. These food courts are for the poor people who are in need of a piece of meal without charging any money.

All buildings were built in masonry with stone and brick. The spanning structural elements are arches, vaults and domes to cover the roofs of these spaces. The most dense use of these structural elements took place in Suleymaniye Mosque to balance the loads coming from the huge dome of the Mosque.

It is told that the most magnificent mosque of Mimar Sinan was built in Edirne for the son of Kanuni Sultan Suleyman, Selim II, named Selimiye Camii. Yes, it is. Because the structural solution of Selimiye Camii is simpler and lighter than Suleymaniye Camii, even though its dome is larger than Suleymaniye's dome's diameter. This means, Mimar Sinan knew how to make the dome be carried with lighter structural elements since. And the effect of the inside of Selimiye Camii is really very magical, when you meet with 8 huge columns, connected with iron bars in single or double forms with the next columns carrying one huge dome. From outside, it is obvious that instead of having domes, there are arches full with windows to get more daylight inside.

When these mosques were compared with each other, we can simply say that Suleymaniye Camii is a full mark as a sculpture in the sky, while Selimiye Camii is also a full mark as another sculpture in the sky but full with lots of windows.

CONCLUSION

When Aya Sofya is looked at from the sky, it can be seen that the foundations above the earth resist against the loads coming from the top dome to the square base, then to two semi domes supported with several small semi domes at the end of the space, while at the right and left sides, there are pairs of support walls to balance the whole structure. After these walls and semi domes, the foundation walls are transferring the loads to the earth. As a conclusion, there is a special space inside Aya Sofya, but there is no clue about this unique space from the outside.

When looked at Suleymaniye Camii from the highest level of Istanbul, it can easily be recognized that the structure of Suleymaniye Mosque in a very clear pattern, as a dome, supported with semi domes in the axis of entrance and at the right and left sides, two huge arches full with windows, in three rows, 19 rectangular huge windows and four circular windows to let daylight fully go inside, supported with a huge, but smaller than the main one at the top, dome and two smaller domes at both sides. And at the same direction with these domes, there are also pairs of stepped stopping walls till to the outer wall of the mosque, then down to the earth level.

At 4 corners of mosque, also there are 4 domes above square bases. Huge semi domes, are supported with 2 small semi domes at the end of the entrance axis while the other huge semi-domes were supported at the beginning of the entrance axis, adjacent to the garden.

Then all spaces are being surrounded by a wide perimeter wall, having additional walls, supporting the perimeter wall at the end of the entrance axis in "Mihrap Area", where all prayers turn to that direction while they are praying. At both sides, right and left with large roofs over 2 stories, with columns linked with each other by iron bars. The structural solution, to resist against loads, is being managed by a framing system, constructed by iron bars, in solid rectangular or circular shapes, horizontal and vertical. Also it may be assumed that there are iron solid bars inside the columns, for, in fact, their diameter is too small due to the loads they carry while spanning the distances between two columns with arches.

In the garden area, there is a courtyard in the meaning of pre-entrance of the mosque. And the surrounding semi covered place with domes in rows, also behaves as a supporting structural system to balance the main system also with 4 minarets going up.

Also, there are 4 small loading towers just after the main dome, also having 6 supporting portals, or in another calling as buttresses at both sides of the dome, just 2 of them are over the huge arches, while 1 is at one side of one arch, the other one is at the other side of the arch.

As a conclusion, it may simply be said that Suleymaniye Camii, is a very successful construction production of 16th century, for 7 years (1550-1557), in Turkey, in the history of Construction branch of that period, while Renaissance was taking place at the same time in Italy in the history of Art.

Mimar Sinan (1489-1588) managed to define a structural system, composed of domes, semi domes, arches, iron bars and masonry walls, that had been very well painted over the whole construction, while Michelangelo (1475-1564) did manage to paint the Sistine Chapel for 4 years in 1508-1512 in art, and also while Michelangelo was redesigning the dome of St.Peter's Basilica in Rome which had double dome as in Florence Cathedral, in construction, until his death.

After Suleymaniye Camii, Sinan built Selimiye Camii, with a similar construction vocabulary. Then Blue Mosque, Sultanahmet Camii, at the end of 17th century again has a similar pattern to Sinan's mosques. But no more mosques like Sinan's, have been built since.

Sinan's efforts for dome and arch construction, and its supporters signed a very important period in the history of construction also in the name of sustainability, mostly in Turkey, in the meaning of being able to create huge and unique and one space under one roof to collect all people for one aim just 450 years ago.

A structural system, composed of domes, semi domes, arches, iron bars and iron solid sections with masonry, brick and stone, is defined by Mimar Sinan to create a unique space under one roof for one aim, in 16th century.

"Form follows function" comment can be used for this mosque as "here, loads follow the structural elements in the most efficient way from top to the foundations, very clearly. Then, it can easily be seen that the inside composition of the mosque through the structural solution, when seen from outside the mosque.

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