MİMAR SİNAN, THE ARCHITECT OF SÜLEYMANİYE CAMİİ, İSTANBUL, TÜRKİYE

Prof.Dr.arch. Yesim Kamile Aktuglu

Dokuz Eylül University, Faculty of Architecture, Department of Architecture, Structure-Construction Branch, İzmir/TÜRKİYE

***Abstract**: Mimar Sinan, who had a life time, nearly for a century, did build very important structures and buildings of Ottoman Empire, till the end of his life in 1588.*
In the construction of the structures and buildings, Mimar Sinan tried novel techniques and solutions in his every next construction with success.
For he traveled a lot and often with the Ottoman Army to everywhere over the continents, he could be able to meet with lots of built examples in the world.
Through his visits to such kind of real structures and also through his experiences about building and constructing, he had a very professional and advanced decision system how to construct buildings and structures, correctly and still in service for centuries.
Süleymaniye Camii, is a very important landmark, having a very clear structural system, easy to follow the loads, starting going down from the top of the dome to the end point of the building, where the foundations are in the earth.
In the paper, the main principles of how Mimar Sinan did construct the structures and how he did solve the structural systems of the buildings, all compose the architectural heritage of Türkiye, still in use today's conditions, will be explained through Süleymaniye Mosque, built in 1550-1557, in İstanbul, by Mimar Sinan.
The aim of the paper is to give an idea about the way how Mimar Sinan designed his proposals, in 16th century, to let others know the secret of him to support a better environment today, in 21st century.

Key words: *Mimar Sinan, Süleymaniye Camii, architectural heritage, novel techniques, İstanbul*

1. Introduction –

Istanbul as the busiest city of Türkiye, which is over two continents, Asia and Europe at once, has lots of architectural heritage, built by Mimar Sinan. As the Great Architect of Ottoman Empire, Mimar Sinan did build and construct so many buildings and structures, having different functions and also all of them are in urban scale, to compose the city and then the country. In his every building and structure, he did try an advanced technology to support novel techniques. The masonry structural system reached to its peak, to pass the large spans at once, by domes and arches.

Mimar Sinan did manage to design holistic total spaces, by challenging with loads to down through correct paths, starting from the top of the domes or arches and ending in the foundations under the earth.

In the paper, Süleymaniye Camii(Fig.1.a), Fig.1.b)), which was built in 1550/1557 [1] in the mid of the Süleymaniye Külliyesi, in Istanbul, Türkiye, by Mimar Sinan will be

examined through its magnificent structural system solution to let it be a light for the Mimar Sinan's building and construction technology[2] . The Süleymaniye Külliyesi has also other buildings, surrounding Süleymaniye Camii in the mid of the Complex as schools, kitchen, baths, hospital, and more to compose a campus area to support the education and healthy development of the people living in the Ottoman Empire, in the name of Kanuni Sultan Süleyman, who was the tenth Sultan of the Ottoman Empire.

The Structural System of Süleymaniye Camii is very important to create a total space under a main dome.



a) b)

Fig. 1. While getting closer to Süleymaniye Camii, through Süleymaniye Street, by walking: a) the view of the main dome; b) the main dome; (photos by YKAktuglu, on 8th of June, 2018)

2. THE STRUCTURAL SYSTEM OF SÜLEYMANİYE CAMİİ

Süleymaniye Camii was constructed with the stone masonary structural system, as stone perimeter walls, stone columns, main dome, semi domes, arches and flying buttresses to support the base of the main dome, not to be damaged due to the pressure of the main dome(Fig.2.a), Fig.2.b))



a) b)

Fig. 2. While getting closer to Süleymaniye Camii, through Süleymaniye Street, by walking: a) the view of the total top structure; b) the ending wall where the mihrab is, with supporting walls to get the full stability of the perimeter wall; (photos by YKAktuglu, on8th of June, 2018)

Main Dome above the base of dome, dome pulley, which has serial window openings to get daylight in, has flying buttress at both sides of the main axis, passing through the entrance door from the courtyard to mihrab, at roof level. Roof structure of the mosque has a main dome, above a square plan, having four huge columns at the corners and four huge arches between columns. At roof level, according to main axis, at right and left sides, the arches are supported by itself, having side walls under the arches, with window openings at three levels, to get daylight in. At the main axis, the arches, carrying the main dome are supported by two semi domes at both ends. At the lower level of these semi domes, there are smaller semi domes to support the larger semi domes, through arches.

By arches full with windows, the unique space under is becoming full with daylight. By semi domes, and smaller semi domes, the unique space under is getting larger.

Fig.3.a) shows the main dome, with windows and flying buttresses, main arch, top of huge column, coming up, and the main pathway for loads, going down. Fig.3.b) shows flying buttresses closer, over the main arch, full with window openings.

All window openings are having double window frames, here outside, and also inside. There are voids between two window frames, to protect the weather temperature and also a perfect barrier for sound isolation.

At the top double window frames, there is a solid iron bar section, passing inside the void to surround the dome to protect it by getting the tension loads in safety.



a) b)

Fig. 3. Main Dome structure : a) it is easy to follow the pathway for the loads going down through the dome, pulley, column, arch, flying buttres, and stepped wall; b) outer window openings together with the whole structure; (photos by YKAktuglu, on 8th of June, 2018)

While looking closer towards roof structure, the whole structural elements are seen clearly in Fig.4.a) and in Fig.4.b). While loads are going down from the top point of main dome, the whole roof top is looking like a pyramid. In other words, the top point indicates the sky. The whole outlook of the mosque is in the service of the loads to be carried in safety. What is really interesting, nearly all walls and dome walls are having double wall layer due to the double window frames over. From one side, this solution makes the structural system lighter and from other side, the structural stability of the mosque gets more importance to last till now along more than 460 years.
The 4 columns have domes at the top of the columns, to indicate the columns from outside. It is easily understood, that while some area in the section of the column is getting the loads from the arches, some area goes on holding the dome stable.



a) b)

Fig. 4. Total view of the top structure: a) Main dome with other domes; b) Main Dome with 6 flying buttresses at one side; (photos by YKAktuglu, on 8th of June, 2018)

The southwest view of the mosque (Fig.5.a), Fig.5.b)), the texture of structural system could be seen very clearly, where the loads are coming down through the structural elements, both at roof level and also of the building as they are at ground floor and first floor.
The main dome and semi domes and smaller domes together with arches are composing the roof levels, while arches with iron bars are composing the ground floor and first floor.

There are two entrance doors, under the porticos from the southwest side of the mosque.



a) b)

Fig. 5. Southwest view of the mosque: a) Main dome, main arch, smaller domes, arches to carry the slabs where smaller domes are transferring the partial loads on; b) southwest view of the building after the three arches to carry the slab above, with eaves and arches, connected with iron bars to get the tension; (photos by YKAktuglu, on 8th of June, 2018)

One of the entrance doors at the southwest façade, which is closer to the starting perimeter wall, where the mihrab is on (Fig.6.a)) is having three arches to let the people pass under them to enter in. Over this entrance portico, there are three domes to get the attention for entrance to the mosque. And this part is being carried by another arch, having three windows over the wall under the arch, to get the daylight in. The iron bars are for the entrance arches to let them stay in stable.

At the first floor, nearby terrace of the entrance, composed by arches and columns, the roof structure is a sloping structure with eaves to get the human scale for the prayers outside (Fig.6.b)). There are arches, connected with iron bars, at the first floor also



a)



b)

Fig. 6.: Details of southwest side of the mosque: a) Entrance canopy from the southwest side of the mosque, with three arches and three domes; b) first floor of the southwest side of the mosque, with arches, connected with iron bars, having a sloping roof with eaves; (photos by YKAktuglu, on 8th of June, 2018)

The courtyard of Süleymaniye mosque has a rectangular plan, surrounded with arches with dome structures(Fig.7.a)). The composition of the domes in front of the courtyard entrance from garden has a special architectural design as a three storey-high building is welcoming the prayers in the courtyard, to get the stability of the archway at four sides of the courtyard. Also the mid dome, just above the entrance door to the courtyard (Fig.7.b)), is at a higher level than the other 8 domes at one row, as the mid dome, just above the entrance door to the mosque, is at a higher level than the other 8 domes at one row. And also there is a height difference at a higher level, between the row in front of the entrance side to the mosque and also the side dome rows.



a)



b)

Fig. 7. Courtyard of Süleymaniye Camii: a) the entrance from the garden to the courtyard, surrounded with arches over columns; b) the entrance to the mosque from the courtyard, with a main entrance dome, in front of the main entrance facade of the mosque; (photos by

YKAktuglu, on 8th of June, 2018)

In the inner view of the mosque, there is a lamping system, hang down from the main dome, which creates a human scale in the name of the height till to the candle lamping, kandil in past. Behind the lamps, the main structural system, to carry the loads of the main dome, can be seen, with main arch, pendentives [3, p.329] between arches, three arches to carry the semi dome, supporting the thinner arch, columns and balkonies at two different levels as they are in Fig.8.a). The better view of the total space can be understood in Fig.8.b



a) b)

Fig. 8. Inner view of the mosque towards mihrab, to southeast direction: a) the view is from the end level of the main dome till ground floor, between two columns; b) the inner view with the left side arches and columns; (photos by YKAktuglu, on 8th of June, 2018)

In Fig.9.a) and 9.b), the sacred main dome and semi domes, arches and smaller semi domes how how they do span over the total holistic space beneath.



a) b)

Fig. 9. Inner view of main dome, semi domes, smaller semi domes: a) together with four arches to support the main dome at the top; b) with semi domes also; (photos by YKAktuglu, on 8th of June, 2018)

Under the main arches, as it is seen in Fig.10.a) left side of the mihrab and in Fig.10.b) right side of the mihrab, there is a double section spaces to enlarge the inner space of the mosque.



a) b)

Fig. 10. The composition of main arches and windows and smaller arches under: a) northeast side composition; b) southwest side composition; (photos by YKAktuglu, on 8th of June, 2018)

The main columns are in fact very fat, but also there are tricky designs of the main columns to indicate the main columns thinner than their real dimensions, as it is seen in Fig.11.a) and in Fig.11.b).
Pendentives between the two arches and also the base of the main dome, are adding additional value to the architectural design quality of Suleymaniye Camii.
Arches with iron bars, are enough strong the get the upper loads.



a) b)

Fig. 11. Main columns, closer to mihrab, with the total structural system: a) northeast main column; b) southwest main column; (photos by YKAktuglu, on 8th of June, 2018)

In Fig.12.a) and Fig.12.b), the additional spaces at both sides of the main dome area, are helping the environments enlarge more.



a) b)

Fig. 12. The composition of the arches and columns under the main arches to carry the main dome: a) the structural composition to design an additional space to the main space to make the main space be enlarged; b) the view of the additional space behind the three arches; (photos by YKAktuglu, on 8th of June, 2018)

In the Northeast facade, the arches, compose a rectangular base for the dome structures, as well as the arches at the ground level, compose the first floor slab carriers. In Fig.13.a), this can be seen. In Fig. b) gate to the courtyard can be seen.



a) b)

Fig. 13. The northeast view of the mosque: a) all structural texture, composed by main dome, flying buttresses, semi domes, smaller domes, arches, columns are altogether; b) the entrance gate to the courtyard from garden of the mosque; (photos by YKAktuglu, on 8th of June, 2018)

In fact there are 4 minarets [2, p.297]at four corners of the courtyard. All these minarets can be expected also as the stability elements of the courtyard. In Fig. 14.a) there can be seen 3 minarets at once. In Fig. 14.b) the total roof structure at the Nortwest façade can be examined.



a) b)

Fig. 14. The view of the mosque from the north corner of the garden: a) the minarets, 3 of 4 are standing up at the corner points of courtyard; b) northwest view of the roof structure of the mosque; (photos by YKAktuglu, on 8th of June, 2018)

Mimar Sinan preferred a simple area to sleep, and maybe it is the best place, for it is really at a very real city centre of Istanbul.



Fig. 15. Mimar Sinan's sleeping place (photo by Y.K.Aktuglu on 8th of June, 2018)

Süleymaniye Camii has a huge garden area around the mosque and its courtyard. The wall surrounds the garden area lets the streets go around the mosque. Just across the street corner, the Great Architect of Süleymaniye Camii, Mimar Sinan, rests at his place, seen in Fig.15.

3. Conclusion

Süleymaniye Camii is one of the best mosques of Mimar Sinan to represent the successful outcome of mosques having main dome with semi domes and arches to support the main dome, to create a total space under. Also by remembering that it was built according to the rules of how to build a stone masonry mosque building, it may be clearly understood that how deep knowledge exist in the buildings and structures of Mimar Sinan, mainly in Türkiye and also in the world.

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I am very thankful for the partnership of my colleague, came from DC to visit Istanbul. We have visited Süleymaniye Camii on 8th of June, 2018.

Note

Before this paper, there were,

[1] several technical visits to Süleymaniye Camii with architectural students, colleagues and by myself, in past.

[2] several scientific papers about Mimar Sinan and his 7 mosques, written by a group, including me and my 6 colleagues.

[3]A research project aboutin the name of the sustainability of Mimar Sinan's 7 Mosques in Türkiye, supported by TÜBİTAK, Turkish National Scientific Research Institution, prepared by me and 6 colleagues, at the same time with COST Action C25, Sustainability of Constructions, which all of us (7team members), were team members of C25.

This paper, is prepared after a visit to Süleymaniye Camii on 8th of June, 2018. During the visit 469 photographs were taken by Y.K.Aktuglu, on 8th of June. 2018. Through 469 photographs, the results were gained, and explained with photographs.

REFERENCES

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[2] 469 photographs, taken by Y.K.Aktuglu, on 8th of June, 2018

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