Understanding the Mathematics Based Formulation on Dome Tessellation in Architect Sinan's Mosques Design

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The K-12 education is a comprehensive learning program, which includes curriculum, tools, materials and an innovative lesson delivering system. In college education, it is not always easy for teachers to have students' attention in history lessons. According to the description of K-12 education, some new teaching methods should be suggested to students on their history learning program for helping them to understand the history easily.

In general history lessons, the world history is told by giving the dates of events and mostly using some "spectacles", which are looking through "war history". The reasons and the results are important on history and they are always related with each other. Sometimes for better understanding the reasons and results of socio-cultural based relations should be researched on history education. The history of architecture gives lots of clues on that point of view. Thus, the Ottoman Empire can be chosen as an example for this workshop. The aim of this workshop is to understand the reason-result relationship on the creation of dome tessellation of architect Sinan -while designing structure for a specific dimension- by interactive education. To fulfil this aim the workshop will evaluate the usage of the dome structure in Sinan's mosques as the result of technology and material.

The Ottoman Empire was one of the biggest empire of the world history. And Sultan Suleiman the Magnificent period was the Golden Age, not only because of the treasury, but also because of developments on the socio-cultural life; and mostly on the architecture by Architect Sinan's designs.

During the Ottoman history, monumental sized buildings have been constructed by sultans to show their power. Mostly these buildings were mosques. The size of the mosque has been created according to the tradition of the praying lines facing to the Kibble[1] while namaz[2]. Thus, the main aim is to cover the "x" distance of praying medium (downwards-to-upwards).

All over the history the monumental mosque has not only been the symbol of the sultan ruled the Empire, but also the symbol of the Imperial Power in that age. Using this monumentality of structure was the priority of Architect Sinan's designs, who was one of the superior architect-building engineers of his age with Michelangelo. The proof of this is his stone masonry structures are still "alive"/ survived within last

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[1] Kible: the direction of Mecca.
[2] Namaz: the ritual worship of muslims, five times a day.
[3] Pendant: circular triangle; a structural element of roofs or ceilings

400 years. Structure is the most important point of Architect Sinan's designs. Instead of using downwards-to-upwards space organization in mosques, Architect Sinan created the medium from "x" distance dome (upwards-to-downwards). He created the main dome first; extend over an area, using the maximum limits permitted by the material and the structure. Thus, his method is "dome tessellation". Definition of tessellation is a collection of shapes that fit together to cover a surface without overlapping or leaving gaps. Often a repeating geometric pattern, may of which may also be referred it to as tiling. Types of tessellation include translation, rotation and reflection. The study of tessellation can integrate many disciplines across any full curriculum-in art, math, language arts, social studies, etc. (www.artlex.com, lexicon of visual art terminology).

The organization of dome tessellation in Architect Sinan's designs are various in types, however, the theory is the same. The unity in his designs is to generate the space organization from the dome tessellation. There is always a main dome at the centre. Force coming from the main dome is supported by semi-domes at sides, quarter-domes at corners and pendants[3] at the transition to the base of the building. And finally, at the façades, arches are used to carry the force coming from the structural elements.

Geometric definitions of structural elements of tessellation are given below.
Main dome = approximately half sphere,
Semi-dome = either half sphere or quarter of a sphere,
Quarter-dome=either half sphere or quarter of a sphere,
Pendant = triangular sphere

Selected examples are shown on the following pages
1. Suleymaniye Mosque
Construction period : 1550-1557, under the reign of : Sultan Suleiman the Magnificent
2. Selimiye Mosque
Construction period : 1568-1575, under the reign of : Sultan Selim II
3. Shehzade Mehmed Mosque
Construction period : 1543-1548, under the reign of : Sultan Suleiman the Magnificent
4. Mihrimah Sultan Mosque
Construction period : 1540-1548, supported by : Mihrimah Sultan
5. Kilic Ali Pasha Mosque
Construction period : 1580, supported by : Kilic Ali Pasha

References

[1] A. Kuran, Mimar Sinan, Hürriyet Vakfı Yayınları, Istanbul, 1986.
[2] N. Camlıbel, Sinan Mimarliginda Yapı Strukturunun Analitik Incelenmesi, YTÜ Yayinlari, Istanbul, 1998.
[3] R.Gunay, Mimar Sinan ve Eserleri, YEM Yayin, Yapi-Endustri Merkezi Yayinlari, Istanbul, 2002.

*Images number 3-4-7-9-11-14 are from N. Camlıbel, Sinan Mimarliginda Yapı Strukturunun Analitik Incelenmesi, YTÜ Yayinlari, Istanbul, 1998.

Image number 1 is from R.Gunay, Mimar Sinan ve Eserleri, YEM Yayin, Yapi-Endustri Merkezi Yayinlari, Istanbul, 2002.

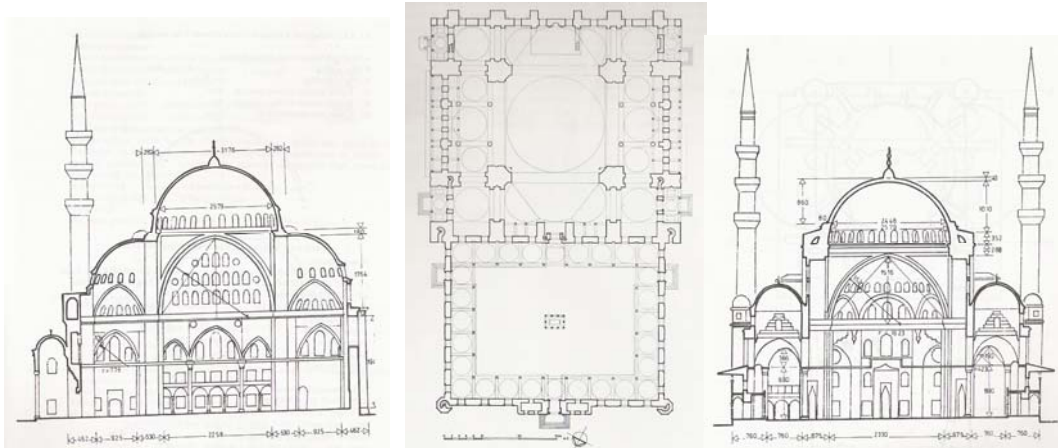All of the other images are from A. Kuran, Mimar Sinan, Hürriyet Vakfı Yayınları, Istanbul, 1986.

Figure 1, *Plan and cross-sections of the Suleymaniye Mosque, Istanbul-Turkiye*

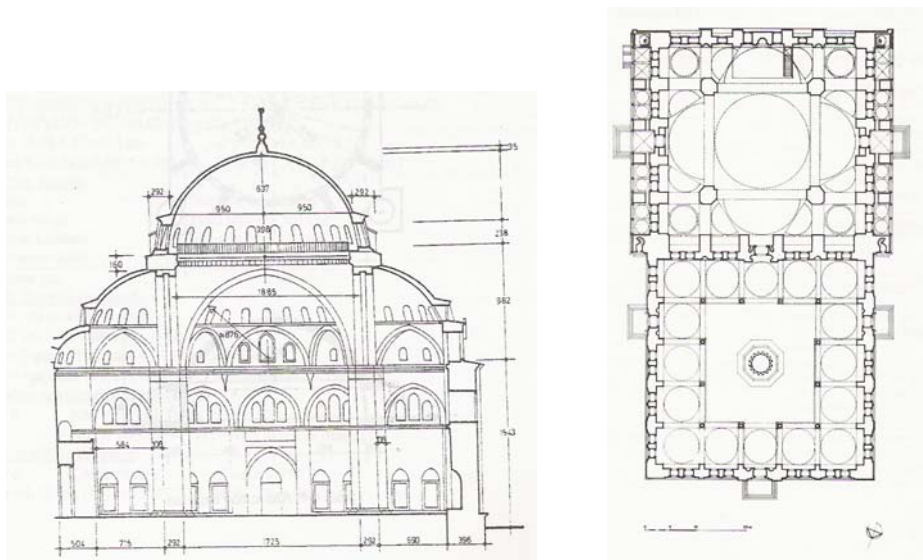**Figure 2**: *Plan and cross-sections of the Selimiye Mosque, Edirne-Turkiye*

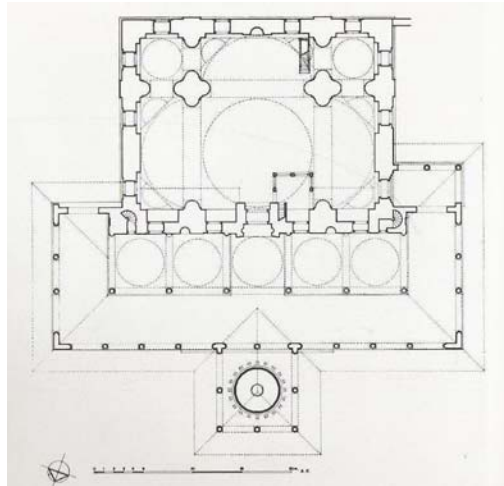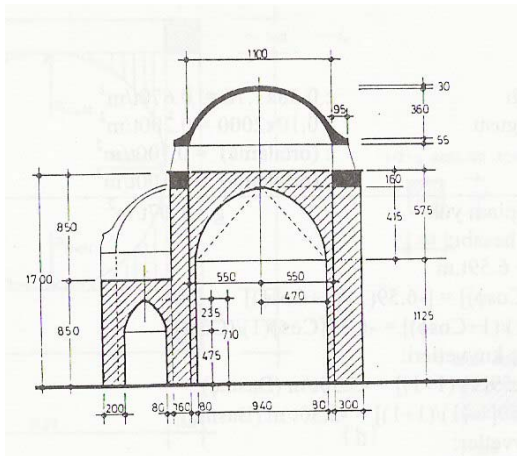**Figure 3**: C*ross-section and plan of the Shehzade Mosque, Istanbul-Turkiye*

Figure 4: C*ross-section and plan of the Uskudar Mihrimah Mosque, Istanbul-Turkiye*
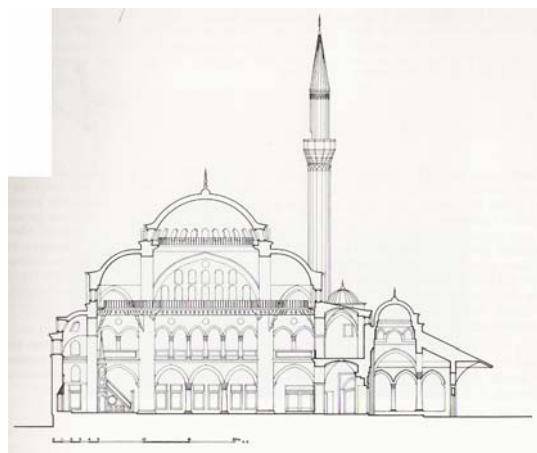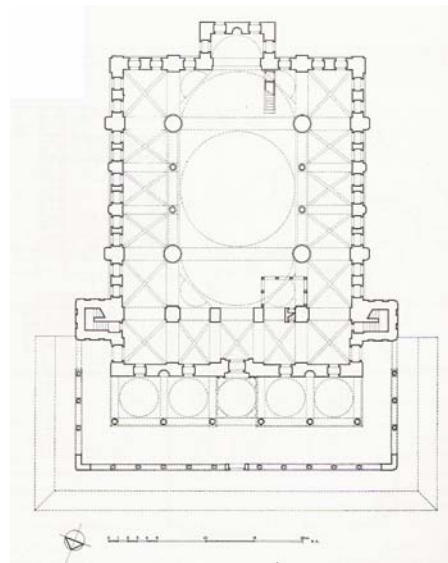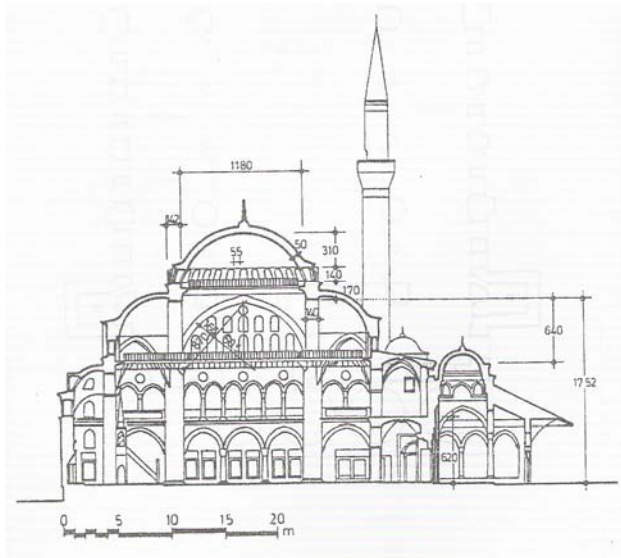

Figure 5: C*ross-sections and plan of theKilic Ali Pasha Mosque, Istanbul-Turkiye.*