



## AN EVALUATION OF NATURAL LIGHT DIFFUSION IN SPACES WITH LANTERN DOME: DİVRİĞİ GREAT MOSQUE

Tuğçe ÇELİK<sup>1</sup>

Nakiş KARAMAĞARALI<sup>1</sup>

<sup>1</sup>Gazi University, Architecture Faculty, Department of Architecture, 06570, Ankara, TURKEY

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### Abstract

Light gives a distinctive characteristic to the spaces with lantern dome that has a special place in Turkish architecture. In this study, "the lantern dome" has been handled in a holistic view with its form and meaning. In order to understand the effect of light in spaces with lantern domes and to make analytical interpretations, a number of analyzes were made on the example of Divriği Great Mosque by the computer programs used. The analysis presents the features that light provides to the spaces and the semantic perspective of light and spaces with lantern dome.

## 1. INTRODUCTION

In designing architectural space, light which enables perception to the space and plays a major role in giving meaning and character to the space, has been considered important together with other elements. In addition to the functional usage, the light, which contributes to the identification of the people with the place where they live and creates various images about the environment, has gained more importance in designing during the historical process. The influence of light and its relationship with design is not restricted to its historical, aesthetic and constructive properties, but its psychological characteristics are also discussed indeed. The notion of designing with light became effective in human perception then.

The openings in the space (such as the lantern dome) are the openings that are directed by human and also which directs the human in return. Openings that connect inside and outside of the building and make it's envelope perceptually permeable, have made living in the space possible. In designing such openings, the desired characteristics of the space are taken into consideration and the semantic aspect of it is conveyed to the user.

According to the researches, the dome form that allows the natural light in from the top and which is named as "lantern dome", "lapped dovetail dome" or "overlap cover" has a deep historical background having a long period of use and a large geographical vastness from Central Asia to Anatolia. This perpetuity shows that cultural continuity brings along architectural identity.

In this study, the studies of architectural history researchers on lantern dome has been taken as a basis. With this regard, the form and meaning of lantern domes have been scrutinized and the use of light and its semantic perspective had been examined through the origin and development of them. For this purpose, a literature research has been completed initially. Before passing on to the lantern dome issue, space, light and meaning in architecture have been discussed as the result of literature research. In the light of these discussions, the types of buildings having the lantern dome and its semantic substructure have been examined. A case study has been established followingly which Divriği Great Mosque was chosen as an

example and included in the chapter "An Evaluation of Natural Light Diffusion in Spaces with Lantern dome", in which the illumination value in the spaces with lantern dome and the value of the light have been examined. The reason for choosing Divriği Great Mosque is its being a good example for plan scheme of the closed courtyard with a lantern dome cover, which is a scheme frequently encountered in Anatolian Seljuk mosques. Attendantly it bears a few windows which cause the lack of homogeneous light inside. In the first place, the building was modelled by its real dimensions in AutoCAD Architecture. The model was imported in Velux Daylight Visualizer program in the second step of the method. Here, the construction material and coordinates of the building were entered and then the natural light diffusion and values of the space were taken as visual outputs for the annual and selected dates. As a result of the case study, the effect of light on the space was examined by the evaluation made accordingly with the data obtained. With this evaluation, it is aimed to explain the functional role of light as well as its meaning with symbolic value and its contribution to architectural identity by the meaning it brings to the building. As the result of the analysis, it is claimed that the meaning and the symbolic value could be expressed in an analytical way.

## 2. SPACE, LIGHT AND MEANING IN ARCHITECTURE

Human experiences, culture, geographical environment, form and meaning of space, structure and light are the essential of architecture. Architecture is a concept which is based on concrete notions such as form, space, surface and mass; indicating direction and boundaries together with descriptive features such as color and texture which combining them all with light.

Light as one of the major necessities of life has been the limiting, descriptive and directive element of the architectural space. L.Kahn, who discusses space-light relation in his studies, interprets architecture as "a beginning that exists between silence and light". (Kahn, 1968) Meiss who has a definition of architecture as "Architecture is the art of positioning and controlling light sources.", emphasizes that architecture is directly related to light. (Meiss, 1992, p.21) Besides these definitions, architecture gains a cognitive expression not only with physical features but also with the phenomena and ideas.

Space as the essence of architecture is a limited vacancy which puts people in the center and defines the living space of them. The space with limited vacancy is intended for a purpose and has many physical connections such as environmental and regional issues. However, space becomes a "place" when it assigns cultural, environmental or regional context. The place includes the cultural impact of the environment, along with the humanistic character of the physical space. Every "place" is unique with these environmental, cultural and humanistic characteristics. The place includes cultural features as well as concrete features such as form, material, texture, color and light. (Trancik, 1986, p.113)

An architectural space, independent of all its components, is essentially a vacancy. At this point, the necessity of architecture is to create the space by making it visible, which is essentially a vacancy. Light brings space into existence by making it visible. The user of the architectural space perceives the whole which is made up of the entrance of natural light into the space, the meaning it creates in the mind, the form and the geometry of the space together. This entirely constitutes the meaning of space in the mind and by this way, concludes with an aesthetic judgment about space. Similarly, Aydınli states that, "Architecture, which is regarded as the means of meaning, is defined as a pragmatic and an aesthetic object that reflects humanistic values." (Aydınli,1993)

## 3. LANTERN DOME

In its simplest definition, the lantern dome means the opening in the center of the cover of the space. When this aperture or skylight is examined, basically two uses are seen. The first is the "lapped dovetail dome" built by overlapping wooden beams on to each other to form a dome and the other one refers to the opening in the middle of the dome, namely the keystone.

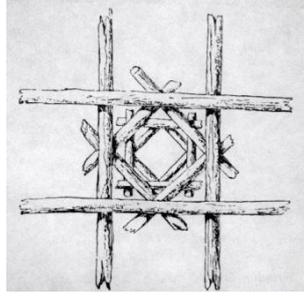


Figure1. Structure of "lapped dovetail dome" (Le Coq, 1925, p.101)

The lantern dome that needs to be emphasized in terms of Turkish architectural tradition is a continuous form of covering. The Turks had lantern dome traditions in both Central Asia and Anatolia thousands of years. According to Akin, "overlap cover" as a variant of lantern dome, has been described as "a construction developed for covering square or nearly square spaces which the dimension of the aperture exceeds the beam's dimension possessed." (Akin, 1991, p.323)

When the factors determining the formation of the lantern dome are examined; climate, material and technology are reached as the results. Climate is an important factor that should be taken into consideration in terms of achieving the necessary comfort level both in the building and in the external environment conditions, that shapes the space.

When the geographical conditions and the climate of the location of the buildings with lantern domes are examined, it is seen that the houses which are the examples of civil architecture were built in cold regions. In the zones where winter season is long and hard, such as Erzurum and Bayburt, especially in countryside architecture, it is thought that the purpose of existence of the lantern dome or especially the overlap cover in the space is the long term and heavy use of the houses and the need of large spaces in them. Akin says that this situation had prepared the physical necessity of the overlap cover. For the same reasons, the building techniques in these houses were expected to be more advanced. (Akin, 1991, p.324-325)

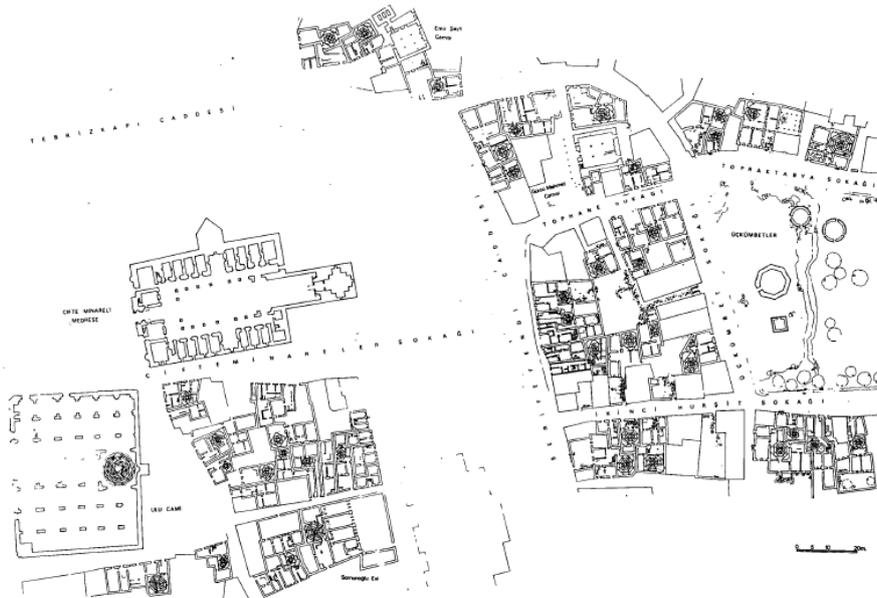


Figure2. Erzurum Great Mosque and houses around it (From the 1976 conservation project) (Akin, 1991, p.349)

When the types of the buildings which the lantern dome is used are examined; it is seen that houses and palaces in civil architecture, cairns and stupas in grave architecture and temples (Buddhist temples) in religious architecture are built in pre-Islamic times. However, in post-Islamic times, houses and palaces in civil architecture, tombs in grave architecture, mosques and religious order buildings (convent, djemevi) in religious architecture, madrasas with closed courtyard in educational architecture are seen.

"The space with overlap cover is an uncommonly impressive space with its unusually blind facade, the plastic configuration of the cover and with the beam of light circulating the dim room like a projector. In addition, this place is a microcosmos like a Central Asian tent; it is at the center of the universe." (Akin, 1991, p.326)

Besides the overlap cover in particular and the lantern dome in general another phenomenon confronted is the transformation of the spaces into sacred spaces in cultures where the dome is used, as it is more or less influenced by the Shamanic beliefs and is containing Shamanist elements. "This space, which is said to carry the identity of microcosmos, represents the image of the Shamanist universe which is made up of three levels (sky / ground / underground) on top of each other. In Kutadgu Bilig, the space with lantern dome constitutes the source of a metaphor for the formation of the universe." (Akin, 1991, p.327)

With its simplest use and plain configuration, the "lapped dovetail dome" that is composed of squares having the same center and being rotated 45 degrees, indicates the eight directions. It is also possible to accept it as a classical mandala form with this feature. (Akin, 1991, p.341) This type of structure, which constitutes a small model of the universe, forms a mandala shape with its square plan and four corner beams in the ceiling construction.

#### 4. AN EVALUATION OF NATURAL LIGHT DIFFUSION IN SPACES WITH LANTERN DOME

In this study, where natural light is analyzed in buildings with lantern dome, the space with the lantern dome is based. The basis of this case study is the lantern dome and the natural light diffusion in the space with this covering.

The methodology at this stage of the study is as follows:



Figure3. The methodology of study

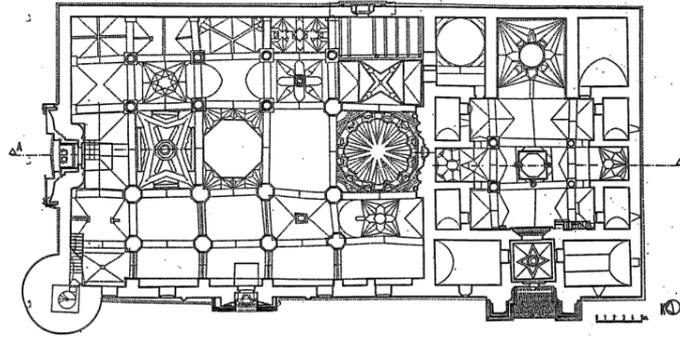
In selection of sample structure, Divriği Great Mosque which has a masonry lantern dome and which is a structure of Seljuk Period, was chosen among Turkish architecture periods in Anatolia. The mosque contains five naves. In the center of the nave, there is a dome that was once open but now closed. One of the most common plan types in Anatolian Seljuk mosques's plan scheme which is a closed courtyard, covered with lantern dome, in fact, the plan of the four-iwan open courtyard with pool in the Great Seljuk Period in Iran was adapted to climatic reasons when the courtyard was decrease and enclosed in the harim and covered with a dome with a lantern. At the same time it is possible to say that the mosque plan scheme with an open courtyard with an iwan emerges from the synthesis of the transept Anatolian basilica. Architecture is a reflection of the concept of cosmos and the universe on the human scale and therefore has a microcosmic plan scheme. The pool in the middle and the dome with the middle hole form a mandala complementing each other in the plan plane. In addition to this, Axis Mundi, which is the vertical axis assumed to pass through the center of the world in the pre-Islamic Turks of Central Asia, appears

semantically in the mosques of the Anatolian Seljuk Period. (Akgül (Karamağaralı), 1997) (Akın, 1990) (Peker, 2007) (Ögel, 1986) (Ögel, 1994)

As a second step, the selected structure was modeled in AutoCAD Architecture programme according to the plan and sections prepared by the architectural historians.

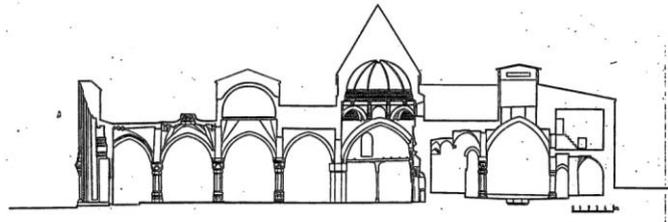


Figure4. Divriği Great Mosque (<http://www.mimdap.org/?p=209336>)



Çiz.32- Divriği Ulu Camii, rölöve planı, (1996)  
Rölöve: Canan Parla-Dilşad Kırıcı-Ayşe Güneyligil  
Çizen : Canan Parla-Hülya Çetin, (1996)

Figure5. Plan of Divriği Great Mosque (Canan Parla)



Çiz.33- Divriği Ulu Camii, rölöve kesidi, (1996)  
Rölöve: Canan Parla-Dilşad Kırıcı-Ayşe Güneyligil  
Çizen : Canan Parla-Hülya Çetin, (1996)

Figure6. Section of Divriği Great Mosque (Canan Parla)

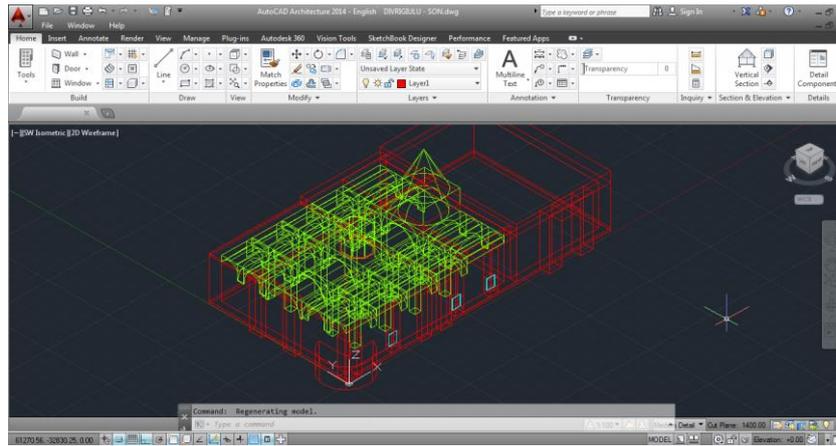


Figure7. AutoCAD 3D model of Divriği Great Mosque

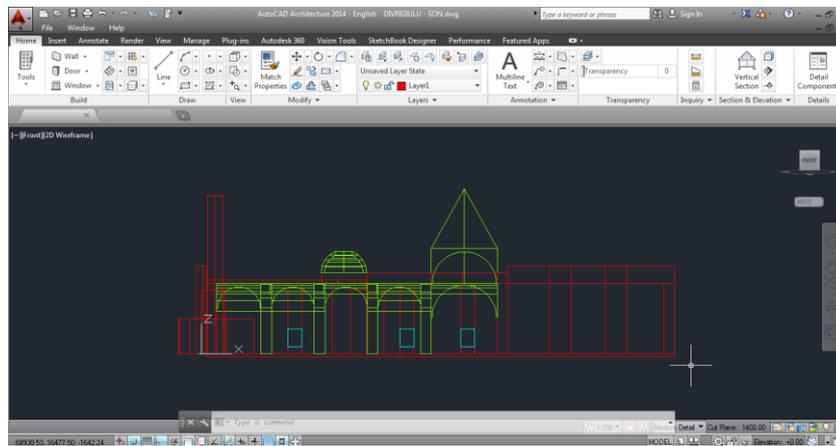


Figure8. View of AutoCAD model of Divriği Great Mosque

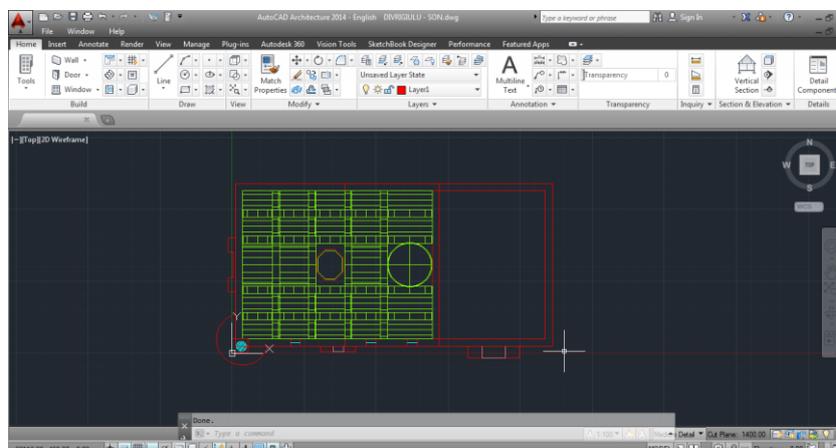
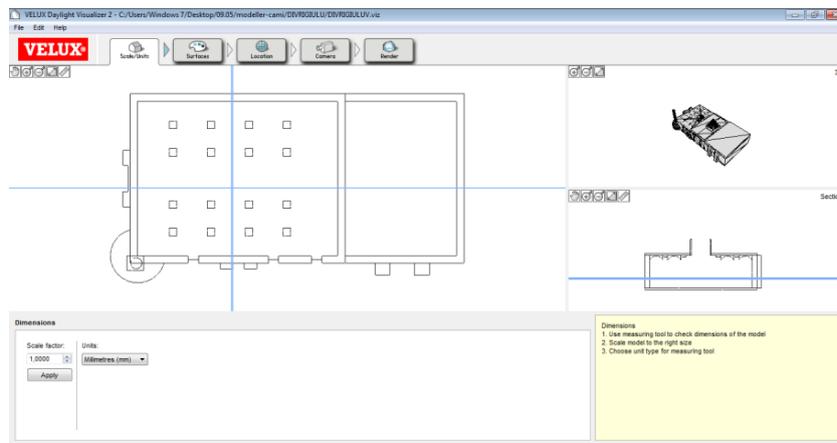


Figure9. Plan of AutoCAD model of Divriği Great Mosque

The 3D model was imported into the Velux Daylight Visualizer program, which shows the light values and diffusion in the space. Velux Daylight Visualizer is a program for all concerned designers, designed for natural lighting design, where space can be modeled in 3D, openings such as windows can be designed, and light and glare values and daylight factor values can be output as visual output. Building components (wall, roof, window, door, surface materials) can be entered as well as the orientation and location of the building can be selected. In this way, the scale was entered for the building model, the material information was entered, the orientation of the building was shown and the location was selected. At this point the parameters are the coordinates of the buildings, the location and orientation of the building, the material of the building, the shape and size of the opening in the building and the dates chosen for the natural light values. These dates are selected as solstices: March 21 equinox, June 21 summer solstice, September 23 equinox and December 21 winter solstice.

**Table1. The parameters of study**

| STRUCTURE   |
|---|
| <ul style="list-style-type: none"><li>•Coordinates of structure</li><li>•Direction of structure</li><li>•Building materials</li></ul>   |
| LIGHTED DOME  |
| <ul style="list-style-type: none"><li>•Shape of opening</li><li>•Size of opening</li></ul>  |
| DATE  |
| <ul style="list-style-type: none"><li>•March 21 - Equinox</li><li>•June 21 - Summer Solstice</li><li>•September 23 - Equinox</li><li>•December 21 - Winter Solstice</li></ul> |



*Figure10. Divriği Great Mosque, Velux Daylight Visualizer*

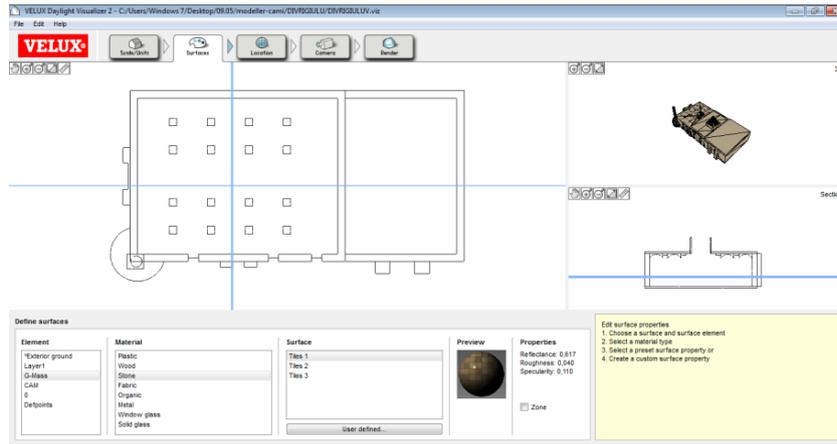


Figure11. Entering building materials of Divriği Great Mosque, Velux Daylight Visualizer

Divrigi Great Mosque is located at 39.371078 latitude and 38.121712 longitude.

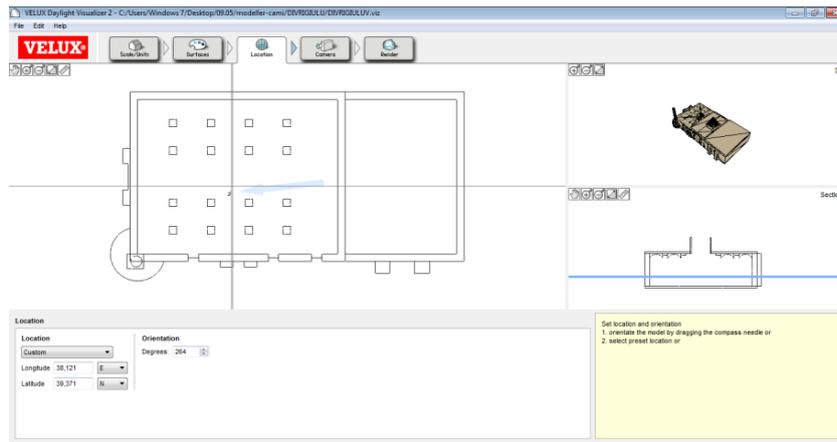
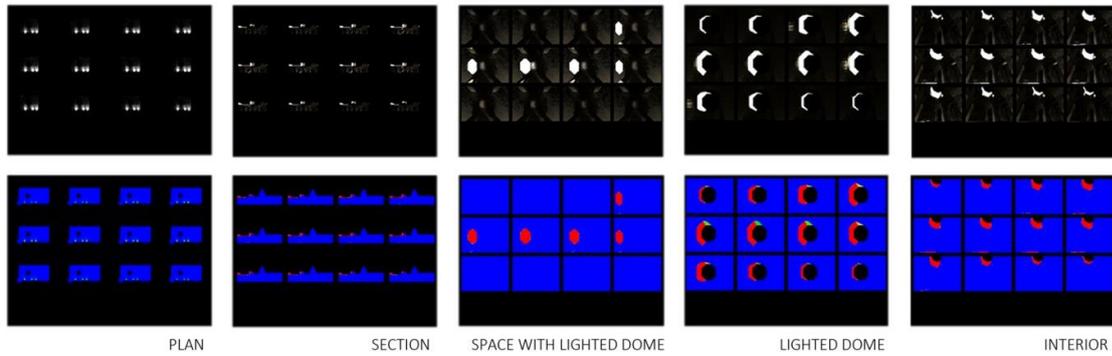


Figure12. Selecting coordinates and direction of Divriği Great Mosque, Velux Daylight Visualizer

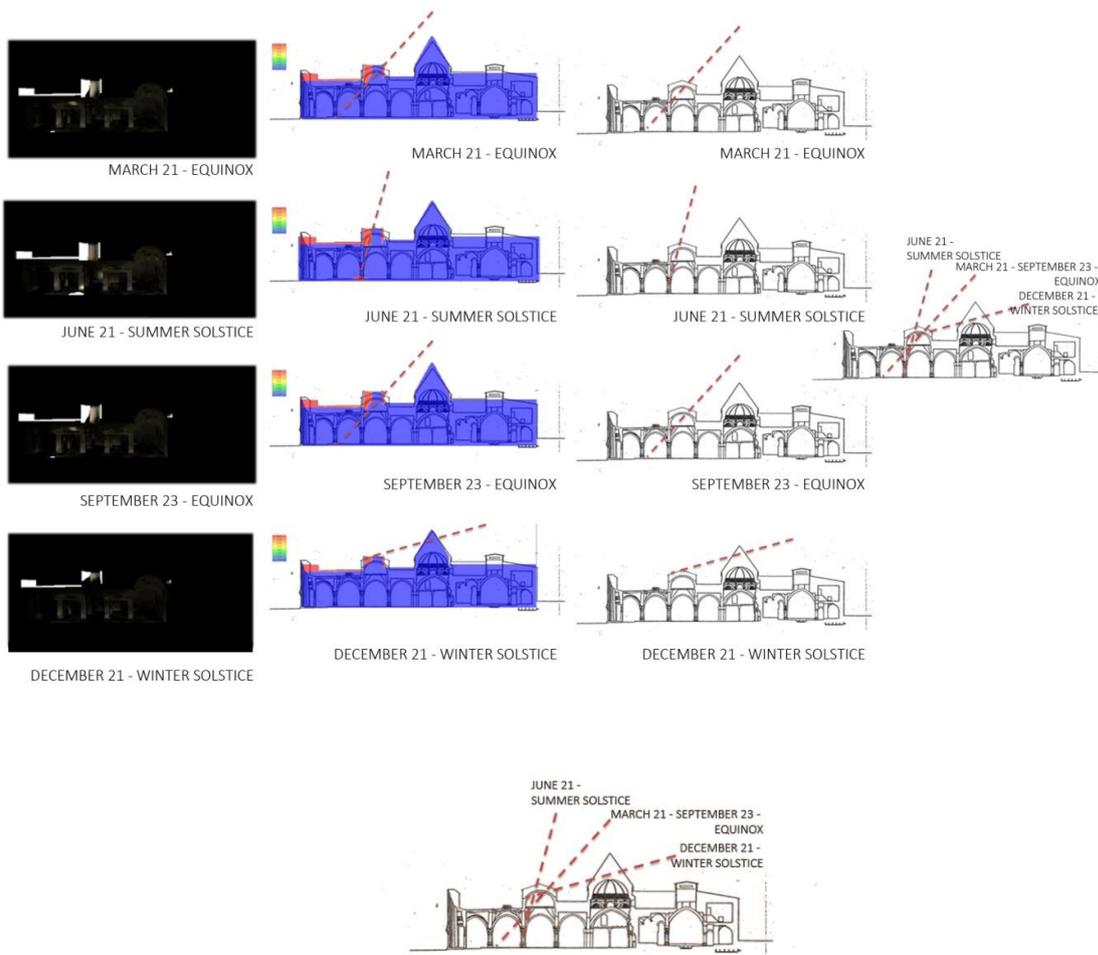
After the model, which was made according to the actual perspectives of the structure, was taken into the Velux Daylight Visualizer program, and the coordinates and orientations were processed, cameras were placed in order to reach the visual output of the natural light diffusions on the specified dates. The program includes the possibility of placing cameras in accordance with the plan, section and interior perspective. Visual output is taken from the perspective of these cameras and left to the user preference. Locations and viewing directions can be changed. In order to obtain visual output, it was decided to look at the plan, space with lantern dome, lantern dome, cross-section and interior perspectives. In this direction, the cameras were placed in the plan, in the plan perspective of the space with lantern dome, in the lantern dome, in cross-section and in the interior perspective. For each point annual diffusion graphics (based on the average luminosity values) that was provided by the program were achieved. In addition, for the cross - sectional and interior perspectives, the values and diffusion of light for the 21 March - Equinox, 21 June - Summer Solstice, 23 September - Equinox and 21 December - Winter Solstice days, and their visual outputs were obtained. In this way, the intake of sunlight from the top and the entrance to the space were plotted on the cross-section in the form of graphic. The light diffusion given by the visual outputs of the cameras placed

in the interior perspective and the brightness values in the interior were reached. In addition to these, it is aimed to make a visual evaluation the image of the structure with the output of natural light diffusion from the interior perspective by overlapping in the Adobe Photoshop program.

**Table2. Divriği Great Mosque annual light diffusion visual outputs**



**Table3. Section of Divriği Great Mosque**



*Figure13. Graphic section of Divriği Great Mosque by dates*

**Table4. Interior perspective visual outputs of Divriği Great Mosque**

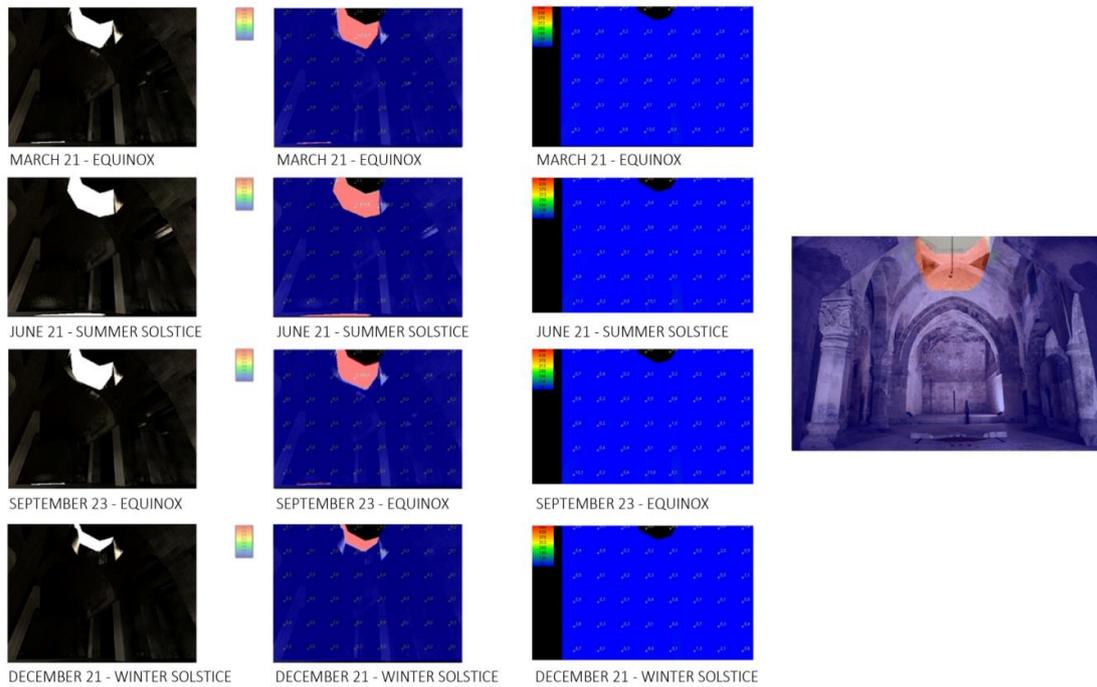


Figure14. Interior perspective, Divriği Great Mosque, Adobe Photoshop

Table5. Illumination values on selected dates of Divriği Great Mosque

|           | March 21 -<br>Equinox | June 21 -<br>Summer<br>Solstice | September 23<br>- Equinox | December 21 -<br>Winter Solstice |
|-----------|-----------------------|---------------------------------|---------------------------|----------------------------------|
| min (lux) | 1.0                   | 0.1                             | 0.1                       | 0.1                              |
| max (lux) | 12.0                  | 15.1                            | 13.6                      | 8.8                              |

In Divriği Great Mosque, which is one of the buildings of Anatolian Seljuk Period, the windowlessness and taking the light from the top to the space only strengthened the center emphasis in the space. The light falling in the middle of the space in the plan of the structure, which only receives the light from the dome that is illuminated from the top, emphasized the center while providing the glare on the surface. Although the central emphasis is provided, the desired illumination level could not be achieved with a single opening. Due to this reason causes of using this covering should be sought in the semantic perspective.

To make a general evaluation when the light diffusion of the structure in the plan is examined; in the half of the year (spring and summer) a more bright level was achieved, while in the other half of the year (autumn and winter) more dimly lit spaces were obtained. The luminance situation provided directly in the form of the lantern dome on the floor of the space does not disappear at any time of the year. As mentioned in the previous sections; with this, centralized understanding is supported. This structure, which has a microcosmic plan scheme that we see in the architectures of Turkish States established in Central Asia, has a central emphasis by the direction of light. This axis emphasizes with its formal and semantic infrastructure. This is also confirmed in the graph of the direction of light drawn in cross-section of the annual light diffusions of the space.

The semantic perspective of the design, which cannot be explained by qualitative features, can be explained in an analytical language with this study. It is thought that the skylight element, which remains functionally dysfunctional has an upper language function (historical references) in architectural communication. The reason for this, dome is being continuity in the architectural culture and using in a culture that has a same continuity. When the semantic infrastructure of the lantern dome indicator is examined, the theology and the conversion of space into a sacred space is perceived as a message transmitted to the user.

In the structure, the light that comes from sky first contacts the top cover. In this respect, when the annual light diffusion of the lantern dome is considered, it remains illuminated almost throughout the year. For this reason, the dome, which is thought to have gained importance in terms of design, also adds aesthetic value to the structure as the symbolic value of space. This dome will be perceived by the users at all times of the year.

## **5. CONCLUSION**

The core of architecture is composed of the existence of the humanistic values, the space with form and meaning, the structure and the light. Form in architecture is a concept that physicalizes the space with concrete concepts such as surface and mass and defined by determinants such as color and texture, and it creates all these by light. Each space is unique with its human character together with the cultural and the environmental content as well as the pure physicality, and it exists with perception. As the result of discussions on space perception, the importance of the space-light relationship has been cognised. Light as one of the major necessities of life had been the limiting, descriptive and directive element of the architectural space. As the conclusion of the discussions it has come to the point that architecture gains cognitive expressions not only by physical features but also with phenomena and ideas.

By the simplest definition, the lantern dome is the central aperture of the cover of the space. The light that affects and shapes the architecture had become special by the way of being allowed into these buildings. When it comes to the semantic analysis, this type of structure, which creates a model of the small universe, forms a mandala shape with its square plan and four corner beams in the ceiling construction.

In chapter 4, the natural light is analyzed for Divriği Great Mosque which has a lantern dome, and the basis of the study is to reveal the natural light diffusion from the lantern dome to the space and the reverse. A number of analyzes were applied with the help of the programs used. As the result of the analysis, it has seen that using blind facades in buildings and taking the light only from the top strengthens the center emphasis in the space. In the plans of the buildings which receive light only from the dome, the light emphasizes the center of the space while it inadequately illuminates the surface of the space. This

inadequate illumination shows that the reason for the construction of this type of dome is mainly semantic but not physically functional, by using the mentioned method of analysis.

The most important result we achieve by this study is that the semantic perspective of light, in other words, light having a semantic value constitutes a very important phenomenon in the formation of Turkish architecture, the Turkish architectural identity and the aspect of space.

## REFERENCES

- Akgül (Karamağaralı), N. (1997). Some Cosmic Motifs and Elements in Seljuk and Ottoman Architecture. *Erdem*, 9(27), 903-910.
- Akın, G. (1990). *Asya merkezi mekan geleneği* (Vol. 1220). Kültür Bakanlığı Yayınları.
- Akın, G. (1991). Tüteklikli Örtü Geleneği; Anadolu Camii ve Tarikat Yapılarında Tüteklikli Örtü. *Vakıflar Dergisi*, 22, p.323-30.
- Aydınlı, S. (1993). "Mimarlıkta Estetik Değerler", İ.T.Ü. Mimarlık Fakültesi Baskı Atölyesi, İstanbul.
- Kahn, L. (1968). *Architecture: Silence and Light*. p.127.
- Le Coq, A. V. (1913). *Chotscho. Facsimile-Wiedergabe der Wichtigeren Funde der ersten Königlich Preussischen Turfan-Expedition nach Turfan in Ost-Turkistan*. Berlin, Dietrich Reimer.
- Le Coq, A. V. (1925). *Bilderatlas zur Kunst und Kulturgeschichte Mittel-Asiens*. E. Vohsen.
- Meiss, V. (1991). *Elements of Architecture, from Form to Place*, Van Nostrand Reinhold.
- Ögel, S. (1986). *Anadolu Selçuklu Sanatı Üzerine Görüşler*. S. Ögel, İstanbul.
- Ögel, S. (1994). *Anadolu'nun Selçuklu çehresi* (No. 58). Akbank, İstanbul.
- Peker, A. U. (2007). *Divriği Ulu Camisi ve Darüşşifası*. Tasarım Merkezi Dergisi.
- Trancik, R. (1986). *Finding lost space: theories of urban design*. John Wiley & Sons.
- İnternet: <http://www.mimdap.org/?p=209336>