The User's Perception of Indoor Comfort Conditions in Historical Mosques: The Case of Bursa, Turkey

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Abstract

The objective of this research paper is to investigate users' perception of indoor environmental conditions in historical mosques, focusing on thermal, visual and acoustical comfort. For this purpose, a user's satisfaction survey was conducted to eight historical mosques' users in Bursa. The study consists of three main parts: i) literature review ii) evaluation of user satisfaction survey, and iii) discussion of the research findings focusing on improving user perception of indoor comfort conditions. Comfort parameters for indoor environment conditions are predetermined by the authors based on ASHRAE 55-92 and ISO EN 7730 standards. The questionnaires were applied to users subjecting indoor comfort parameters of the mosques. In the results and discussion part, the findings of the survey are presented. This knowledge can contribute towards the improvement of future mosque designs addressing indoor air quality, thermal environment, lighting and acoustics.

Key Words: user comfort, indoor environment conditions, historical mosques

1. Introduction

User comfort and indoor air quality are certain issues associated with human health and well-being of society as a total sense of physical, mental and social well-being. World Health Organization (WHO, 2000) reported that maintaining optimum indoor climate in buildings is important for occupants in terms of human health, comfort and productivity. User requirements for indoor air quality and climate are covered American Society of Heating, Refrigeration and Air Conditioning Engineers Standard 55 (ASHRAE, 1992) and The International Organization for Standardization ISO EN 7730 standards (ISO EN, 1994).

A mosque is a sanctuary place for Muslim communities where people gather, pray, study, learn about Islam and receive other services in mosque's compounds. Besides the socio-cultural importance, mosques differ from other building typologies with their unique function and intermittent operating schedule determined by local prayer times. Worshipers gather five times daily and weekly for Friday prayers throughout the year. As a result, the users' physical performance and tranquility are influenced by the comfort conditions of indoor environment. In this context, eight selected case building were evaluated based on the perceptions of comfort in the physical environment, by considering the determinants of indoor comfort conditions including climatic, visual, acoustical comfort aspects.

As being the first Ottoman capital city and trade center, Bursa represents a place of great importance and attracts the attention of inhabitants, researchers and tourist every day. Early Turkish - Ottoman architectural characteristics from 14th and 15th centuries is reflected by several monumental buildings such as khans, bedestens, bazaars, baths, madrasah and mosque complexes (kulliyes) preserved in various historical sites of the city. These group of buildings are immovable cultural and natural property to be legally protected and most of them still maintain their unique functions and authentic architectural value today. This paper focuses on eight historical mosques in Bursa including five Sultan complexes in United Nations Educational, Scientific and Cultural Organization's world heritage list (UNESCO, 2014). Named after the Ottoman Sultans, these complexes situated in Osmangazi and Yildirim districts.

Prior to the field study, a research was conducted on the architectural features of case buildings, together with the literature review on previous studies in respect to the user requirements in religious structures, particularly in mosques. Such research papers dealing with user comfort in mosques were conducted either as subjective studies via questionnaire surveys or as objective studies via computer simulations and experimental analysis of building elements in-situ. Saeed (1996) aimed to measure the level of thermal comfort and evaluate user' satisfaction in the dry desert region of Saudi Arabia. Al-ajmi (2010) performed an investigation on indoor environmental conditions of mosques in dry desert climate of Kuwait by physical measurements and subjective questionnaires. Al-Homoud, Abdou and Budaiwi (2009) assessed thermal comfort of occupants while monitoring the case building's energy consumption in hot and humid climate of Saudi Arabia.

These details later studied by Budaiwi and Abdou (2013) and they identified potential energy savings of HVAC system operational strategies and the impact of envelope insulation in mosques.

Abdul Hameed (2011) evaluated the thermal performance of a new mosque's external envelope by computer modelling and calculations in hot and dry climate region of Iraq. Calis, Alt and Kuru (2015) also aimed to assess thermal comfort conditions of a historical mosque in hot and humid climatic region in Turkey by thermal measurements and user satisfaction surveys. Mustaha and Helmy (2016) calculated and compared the energy demand of three mosque typologies with different architectural forms by a simulation software considering passive and active design strategies to achieve acceptable thermal comfort level in the United Arab Emirates. There are also research papers about indoor and outdoor space quality, site use and facilities are reviewed as; Das et. all (2012) and Sadana (2015).

Today, numerous investigations are carried out worldwide to improve comfort levels of occupants and buildings performance in use; however a limited number of studies have dealt with comfortable indoor climate in mosques with a holistic approach. Compared to research studies on other building typologies, user requirements and environmental comfort studies in historical mosques are limited. Furthermore, most of these research papers address thermal requirements of mosques and reducing cooling loads in energy efficiency context for hot humid and hot arid climate regions conducted in cooling season. This fact further supports the need for this research in temperate climate region.

2. Methodology

The user perception and satisfaction with the indoor environment conditions can be examined from the responses of the user surveys. From this point of view, a field study was conducted to determine user expectations about comfortable indoor conditions in mosques and to what extent these expectations are met. The research aims to cover heating, air-conditioning, ventilation, natural and artificial lighting, indoor air quality, acoustical and visual issues depending on the user responses. The survey is developed based on 5 point Likert scale ranging from absolutely agree to strongly disagree. The questionnaire involves 36 questions regarding the key themes such as: user's view on mosque's architectural identity, safety and ease of access, site use and facilities, thermal, acoustical and visual comfort sensation and indoor air quality perception. The scope of this study is limited to user comfort perception parameters of historical mosques.

Interviews were held in historical mosques of "A class" category which means the investigated symbol mosques are recognized at country level according to presidency of religious affairs in Turkey. To ensure consistency, the field study arranged considering the maximum occupied hours of mosques and carried out simultaneously at the end of the Friday noon prayer, by each member of the survey team. Data is collected on November in 2015 and the total number of responses reached an average of 100 participants for each mosque. The answers have statically analyzed in terms of percentages. The attained results are illustrated in graphs in the research findings section.

3. Architectural Characteristics of Case Studies

Bursa with a population of 2.5 million is the 4th most populated metropolitan city in Turkey. It is located between the south-east cost of the Marmara Sea and the north western slopes of Uludag Mountain. Temperate climate of the region is characterized with warm summers and mild winters. The survey was conducted during the heating season. The selected historical mosques are naturally ventilated and illuminated through window openings. Daylight is supported by pendant light fittings. For climate control, the historical mosques investigated are not equipped with mechanical appliances except standalone air conditioners in some of the prayer halls. The main facade of the mosques are mainly oriented to south-east, towards Qibla. As part of the literature, the basic architectural features of eight mosques are briefly described according to the year of construction in the following section. In Figure 1, studied mosque locations within Osmangazi and Yildirim districts are marked on Google Maps.

Alaaddin Pasa Mosque: Alaaddin Pasa Mosque, was the first mosque built in Bursa by the vizier and younger brother of Orhan Gazi in 1335-1336. The single-unit mosque has a square plan, comparatively small prayer hall with the dimensions of 8.13 m x 8.30 m. The prayer hall is covered with a semi-spherical dome supported on a band of triangular planes. Three bay porticos are roofed with a barrel vault and glazed with arched windows providing sunlight during the day. The building is facing to south-west. There is also a single window above the mihrab, as seen in Figure 2. The conical form of the brick minaret includes a stone base adjacent to the eastern side of the portico. The mosque was built on a former Byzantine site, so the older materials such as the Byzantine columns are repurposed to support altering courses of stone and brick walls (Gabriel, 1958; Baykal 1982).

Emir Sultan Mosque: Emir Sultan mosque in Yildirim district is situated on the lower slopes of Uludag. There are two portals; east and west access to the courtyard of the complex and Emir Sultan mausoleum stands on the mihrab axis of the mosque. The complex is surrounded by an extensive cemetery with tall cypress trees. The mosque was known to be built by Ottoman Sultan Yildirim Bayezit I's daughter in 15th century, demolished in the 1766 earthquake and rebuilt in 1804 after the collapse of the original monument. The complex was also damaged by 1855 Bursa earthquake and restored according to Ottoman baroque design.

The prayer hall of Emir Sultan Mosque is covered by a single dome on a circular drum with squinches. The load-bearing masonry walls are constructed by cut stone courses on the lower portion and alternating courses of stone and brick on the upper portion. There exist two symmetrical minarets at northwest and northeast corners of the structure. The mosque's interior is carpeted, naturally ventilated and illuminated by the windows rising to the upper level of walls (Gabriel, 1958; Baykal 1982). The marble paving courtyard contains an ablutions fountain (sadirvan), as seen in Figure 4.

Orhan Gazi Mosque: Orhan Gazi Complex, consisting of Orhan mosque, madrasah (demolished), and public kitchen (demolished), Turkish bath and Emir Khan, was constructed in 1339. On the north side of Ataturk Street, the complex was the first step for the formation of the Khans area, today known as the commercial and historical center of Bursa. The building is the first example of reverse T-plan mosques (UNESCO, 2014).

It consists of a five-bay portico entrance supported by pillars, a main prayer hall with mihrab niche on the south, one iwan on both sides of the prayer space and two guestrooms located on the sides of iwans. Main prayer section of the mosque is covered with two domes and iwans are covered with smaller domes. The interior is naturally illuminated through the windows in stone and brick masonry walls. Other windows are pierced into the drum of the central dome. The mosque was damaged in the 1855 earthquake and restored a few times. The religious structure was originally built without a minaret, the existing one on the northeast corner is known to be dated to 19th century (Gabriel, 1958; Baykal 1982). The oldest plane tree in Bursa is located in the courtyard of Orhan Gazi Mosque and it provides shade for visitors during summer.

Hudavendigar (Murad I) Mosque: Hudavendigar Complex, consisting of a mosque and madrasah, public kitchen (demolished), Turkish bath and a tomb, is located in a geothermal preservation area in Cekirge district. The complex was built between 1363 – 1366 and it enabled the city to expand westwards in that era. The two storied Murad Hudavendigar Mosque also functioned as madrasah on the upper floor which functionally characterizes and distinguishes the structure from the other mosques. The building has a single minaret on eastern side of the upper gallery. The main hall with the fountain is covered with a dome. Prayer section rises up with five stairs and covered with barrel vault. Two iwans are located on the sides of the main area and four rooms exist in the corners. There are also six madrasah rooms on upstairs, accessible through the staircases on both sides of the entrance hall.

As seen from the outside photo in Figure 6, masonry feet are connected to each other with arches on the facade. The interior picture shows that six windows pierced into the side walls and one above the mihrab that provide sunlight for the main hall and the prayer section (Gabriel, 1958; Baykal 1982).

Yildirim Bayezid Mosque: This mosque was built between 1390-1395 as a part of a complex and the eastern boundary of Bursa. The complex was settled on top of a hill in Cekirge district and originally contains a mosque, two madrasas, public kitchen (demolished), a hospital (darussifa), a khan, a Turkish bath and a mausoleum. Similar to Hudavendigar Mosque, Yildirim Bayezid Mosque has a reverse T-plan and the first example of the Bursa Arch as seen in Figure 7. The building has a symmetrical plan; the narthex consists of five-bay portico, main hall is surrounded by iwans on both side and prayer hall ascended from the main hall with three steps. All these spaces are covered with domes except four rooms located at the corners of main hall are covered with vaults. There exists an ablution fountain in the courtyard. The complex has gone through several restorations following the Bursa earthquakes (Gabriel, 1958).

The Grand Mosque (Ulucami): As an example of early Ottoman architecture with multi domes in a single space, The Grand Mosque was constructed in the city center between 1396 – 1400. The rectangular building with dimensions of 69 x 55 m, has 20 domes supported on round arches on piers arranged in a regular grid. There is a glass dome in the middle of the mosque and it is higher than the rest of the domes. An ablution fountain is placed under this glazed dome. The interior walls are adorned with specimens of calligraphy. Two monumental minarets stands on each corner of the northern facade. There are three portals at east, west, north facades of the mosque and two window lines on each facade, at the top and bottom of the limestone arches. The mosque sustained severe damages due to earthquakes, fires, southwestern wind and invasions in the past and has undergone various restorations (UNESCO, 2014).

Yesil (Mehmed I) Mosque: Built by Sultan Mehmed I (Celebi) between 1414 -1419, the complex consists of a mosque, a madrasah, a royal tomb, a Turkish bath and public kitchen. Yesil 'The Green' mosque is famous for its adornments and decorative blue green Iznik tiles (UNESCO 2014). The authentic tiles can be seen at the sultan gathering place, mihrab niche, and semi-body walls of the mosque, and symbolic coffins at the tomb. The mosque has a reversed T plan scheme, built out of sandstone and facades were cladded with marble panels. Two iwans are located on the east and west side of central hall and there exist four rooms on the north and south side of iwans accessed through the central hall. Two staircases in the vestibule connect ground floor to upper floor where the royal lodge and two adjacent rooms are located. Indoors are lit by windows pierced into the drums of domes as well as through windows in exterior masonry walls. There are balconies on the second floor of northern facade. The existing minarets are known to be added later to the building (Gabriel, 1958; Baykal 1982).

Karaseyh Mosque: Karaseyh Mosque was built in the 15th century. The main prayer section has an almost square form and its dome is seated on an octagonal frame with spiked eaves. As seen in Figure 9, the north facade (narthex) of the building is formed by a high gable wall and divided into three sections with glazed arches. Karaseyh Mosque and its small courtyard on the north is lately renovated (Baykal 1982).

4. Research Findings

At the beginning of this section, survey data consisting of socio-demographic information of the participants is presented. Gender, age, educational status of the respondents are given in the graphs below respectively. Out of total 800 participants, the Graph 1 shows that 28% of respondents are female and 72% are male which indicates that the majority of the respondents are male. Findings in Graph 2 show that, 1% of the respondents belong to under 18 age group, 22% are between 19 – 25, 36% are between 25-45, 30% are between 46-65 and 11% of the respondents are above the age of 65. As shown in Graph 3,14%of the respondents are graduated from primary school, 21% graduated from second dry school, 34% graduated from high school, 7% graduated from vocational school, 23% have bachelor’s degree and 1% have post-graduate degree. The results reveals that there is a diversity in terms of education among the users who participated in the questionnaire.

According ASHRAE Standard 55, thermal comfort is defined as "The state of mind which expresses satisfaction with the thermal environment". Thermal environmental conditions is defined as acceptable when at least 80% of the occupants are comfortable within a space. The comfort temperature is a result of the interaction between the users and the built environment they are occupying.

The clothing level, type of activity and environmental variables such as air temperature, humidity, air velocity and radiation affect thermal sensation and satisfaction of occupants (ASHRAE 1992; ISO EN 1994).

Second part of the survey is about the user perception of comfort conditions in mosques. Twelve leading issues in environmental control context are presented in graphs using a 5-point Likert scale with responses from 1 - absolutely agree to 5 - strongly disagree. The responses illustrated in graphs below, reflect the impact of the current comfort conditions on users perception particularly for indoors. First three questions of the interview are about thermal comfort perception in mosques. The users were asked to express how they feel about the indoor temperature of the mosque during winter and summer seasons. Graph 4 shows the responses for summer, while in Graph 5 the answers reflect the indoor thermal perception in winter. Graph 6 shows the users perception of the mechanical heating and air conditioning system use providing appropriate climate for indoors.

Next questions object to cover acoustical comfort perception of users in terms of acoustical characteristics of mosque volume and sources of noise from indoors and outdoors (Graph 7 – Graph 8 – Graph 9). The users' perception of the existing conditions of visual comforting mosques' prayer halls are illustrated in the graphs below. Indoor daylight and artificial illumination level along with the use of colours are discussed as the preconditions of visual comfort. Graph 10 provides data for daylight use in historical mosques while Graph 11 reflects the user views on artificial illumination.

According to the ASHRAE 62 (2001) indoor air quality (IAQ) guidelines, moisture in building assemblies, poor outdoor air quality, improper ventilation systems, inadequate ventilation rates and indoor contaminant sources are the critical factors to achieve IAQ in buildings. User views were received about IAQ in prayer halls which are crowded by users five times during the day and for Friday prayers. The responses on natural ventilation based on outdoor air flow, the indoor air quality and odor problem are illustrated in the graphs below.

5. Conclusions

The objective of this study is to discover users' views in with respect to achieving optimal comfort conditions in mosques. The comfort perception of respondents in the eight case studies were obtained for indoor air quality, thermal environment, lighting and acoustic issues. In accordance with the survey data, the level of comfort score was voted within -2 and +2. The evaluations are summarized below in Table 1. Negative aspects are marked with bold characters.

Thermal Comfort

Indoor temperature and relative humidity are vital factors for thermal comfort conditions. Historical masonry mosque walls create a thermal mass that reduce temperature fluctuations, prevent overheating and sustain the indoor climate. In all 8 mosques, no fuel based mechanical heating is provided. For the gathering units like main prayer halls, standalone air conditioners were installed for space heating as well as cooling. According to the result drawn from the survey, the users of all 8 mosques are content with the interior air temperature in winter and summer. However, 7 out of 8 mosque users found the use of mechanical equipment inappropriate in summer and winter declaring negative thoughts on the heating and cooling systems.

Acoustical Comfort

As stated in Table 1, acoustical comfort conditions are perceived to be satisfactory in the case studies except for two mosques. Complaints about environmental noise generated by indoor and outdoor sources are reported for Grand Mosque and Karaseyh mosque disturbing worshipper's concentration and prevent the intended use of the prayer space.

Visual Comfort

According to the users' thoughts about indoor illumination of case studies, it has seen that almost all the users are content with daylight level. Considering the windows' size and orientation of external walls, the transparent elements of external envelope allow enough daylight into interiors of mosques. However, visual comfortlessness occurs based on the inadequate artificial sources in Hudavendigar, Yildirim Bayezit, Green and Karaseyh Mosques. The material and colour choice of the internal envelope is important for uncomfortable glare and visual performance in prayer places. The interior walls of mosques are predominantly light coloured except Green Mosque with the decorative blue green tiles. Most of the users stated that the colours of internal envelope is appropriate for users' concentration except Karaseyh Mosque.

Indoor Air Quality

Another factor affects the indoor climate is ventilation. Natural ventilation is the common technique used in historical mosques. Orhangazi, Hudavendigar, Karaseyh and Grand Mosque users expressed that the conditions under they worship are not satisfactory in terms of odor problem. Therefore, IAQ seems to be one the leading problem in these mosques. This fact is supported by another observation that even though mosques have an open-plan layout and greater space height, most of the windows are fixed and operable casements are mostly sealed. Besides improving the quality of carpeting, air circulation should be provided in prayer halls taking into account of actual occupancy levels of mosques given that interior contaminant sources and harmful micro-organisms can emerge in such public places.

This paper aims to clarify the physical environment matters to achieve optimal comfort conditions in mosques by interviewing with the users. Survey analysis show that the perceptions of comfort for all 8 historical mosques can be considered as positive. On the other hand, the survey findings indicated minor issues relating to indoor air quality, artificial lighting, visual and acoustical discomfort. The users can be physically and psychologically healthy, productive and focused in the built environment only if optimal comfort conditions are provided. The results reveal that, achieving optimal comfort conditions is essential to create positive impact on users' perception in religious structures. This knowledge can further contribute towards the improvement of future mosque designs addressing indoor comfort parameters.

6. References

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Figure 1. Location of the Case Buildings: 1)Alaaddin Pasa Mosque, 2)Emir Sultan Mosque, 3)Orhan Gazi Mosque, 4)Hudavendigar Mosque, 5)Yıldırım Bayezid Mosque, 6)Yesil Mosque, 7)The Grand Mosque, 8)Karaseyh Mosque (Google Earth, 2016).

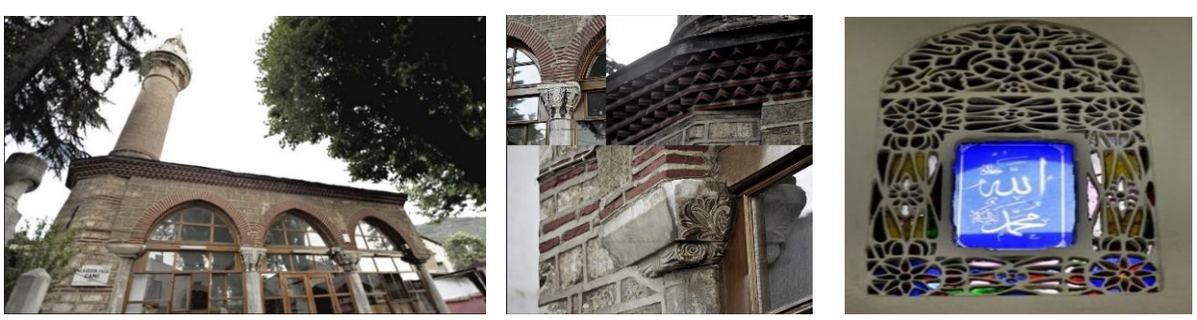


Figure 2. Photographs taken from the outside and inside Aladdin Pasa Mosque

Figure 3. Photographs taken from inside and outside courtyard of Emir Sultan Mosque

Figure 4. Photographs taken from the outside and inside of Orhan Gazi Mosque

Figure 5. Photographs taken from the outside and inside of Hudavendigar Mosque

Figure 6. Photographs taken from the outside of Yildirim Bayezid Mosque

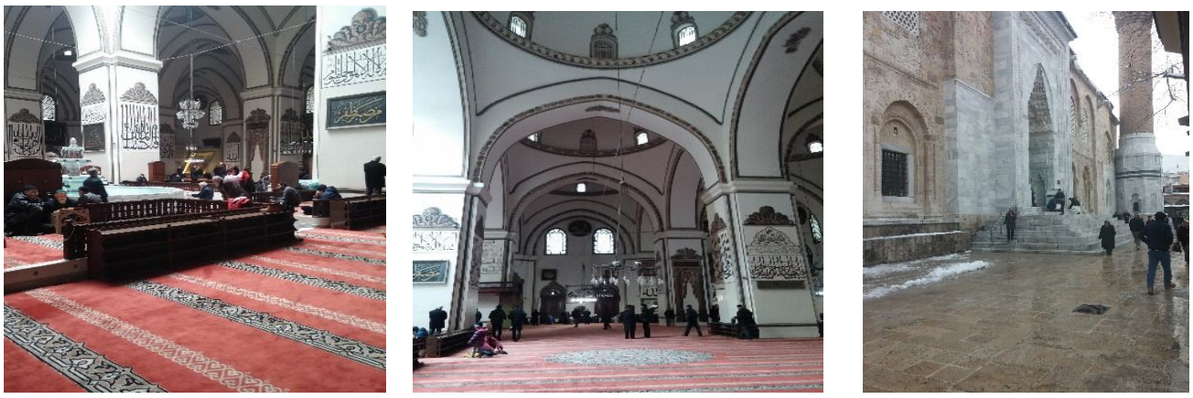


Figure 7. Photographs taken from the inside and outside of Grand Mosque (Ulucami)

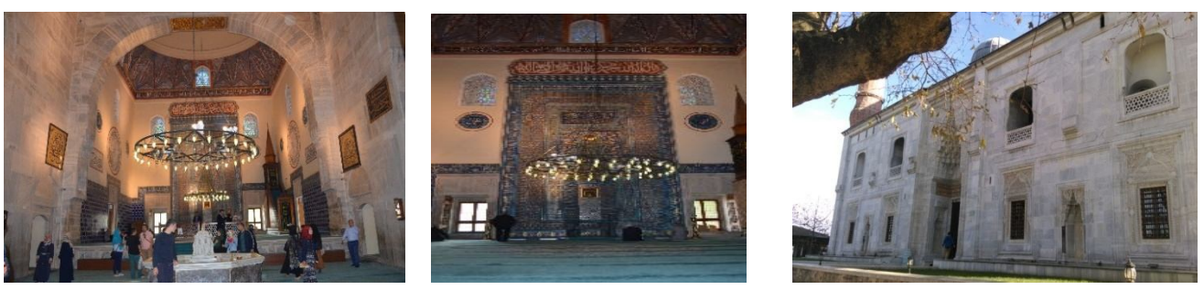
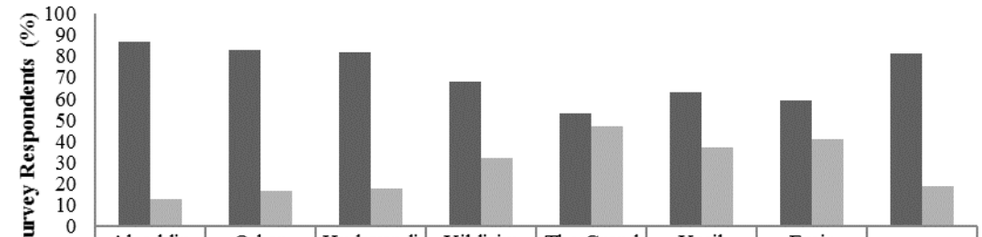


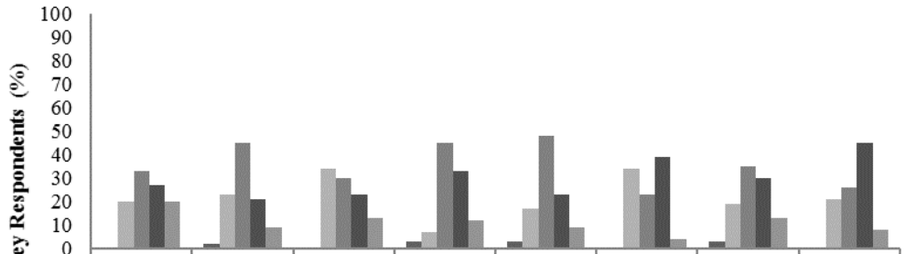
Figure 8. Photographs taken from the inside and outside of Green Mosque

Figure 9. Photographs taken from the outside of Karaseyh Mosque



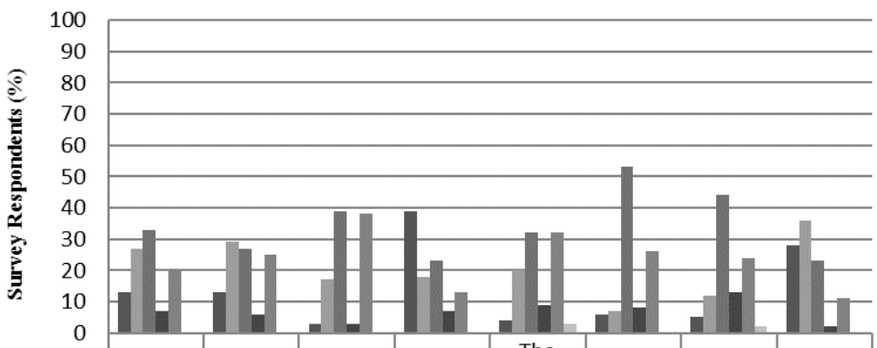
	Alaaddin Pasa	Orhan Gazi	Hudavendigar	Yildirim Beyazid	The Grand Mosque	Yesil Mosque	Emir Sultan	Karaseyh
male	87	83	82	68	53	63	59	81
female	13	17	18	32	47	37	41	19

Graph 1. Gender Distribution



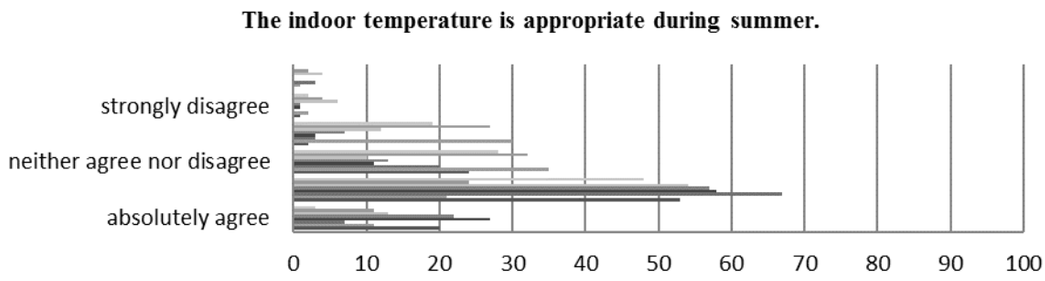
	Alaaddin Pasa	Orhan Gazi	Hudaven digar	Yildirim Beyazid	The Grand Mosque	Yesil Mosque	Emir Sultan	Karaseyh
18 year and under	0	2	0	3	3	0	3	0
19-25 years	20	23	34	7	17	34	19	21
26-45 years	33	45	30	45	48	23	35	26
46-65 years	27	21	23	33	23	39	30	45
65 year and over	20	9	13	12	9	4	13	8

Graph 2. Age Distribution



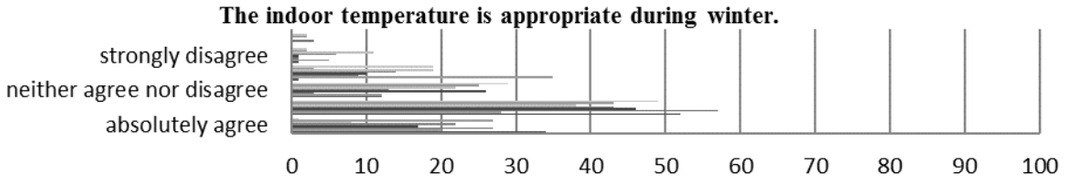
	Alaaddin Pasa	Orhan Gazi	Hudavendigar	Yildirim Beyazid	The Grand Mosque	Yesil Mosque	Emir Sultan	Karaseyh
primary school	13	13	3	39	4	6	5	28
secondary school	27	29	17	18	20	7	12	36
high school	33	27	39	23	32	53	44	23
vocational school	7	6	3	7	9	8	13	2
graduate	20	25	38	13	32	26	24	11
postgraduate	0	0	0	0	3	0	2	0

Graph 3. Educational Status Distribution



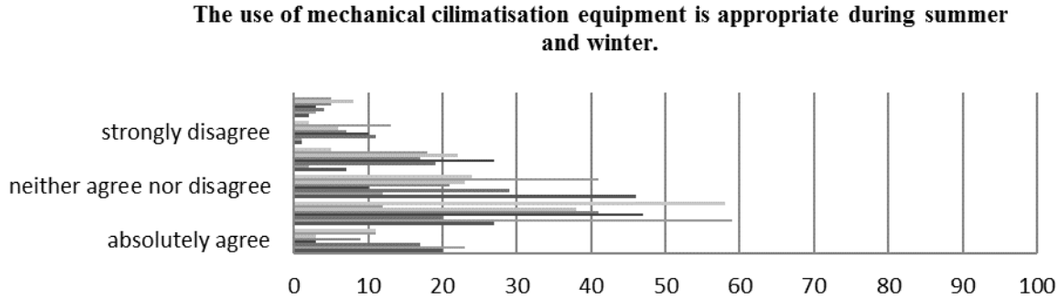
	absolutely agree	agree	neither agree nor disagree	disagree	strongly disagree	can't choose
Karaseyh	3	48	28	19	2	0
Emir Sultan	11	24	32	27	4	2
Yesil Mosque	13	54	10	12	6	4
The Grand Mosque	22	57	13	7	1	0
Yildirim Beyazid	27	58	11	3	1	0
Hudavendigar	7	67	20	3	0	3
Orhan Gazi	11	21	35	30	2	1
Alaaddin Pasa	20	53	24	2	1	0

Graph 4. The user perception of thermal comfort in summer.



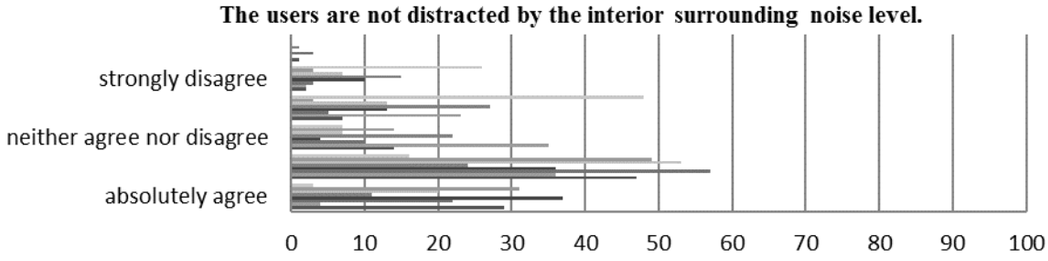
	absolutely agree	agree	neither agree nor disagree	disagree	strongly disagree	can't choose
Karaseyh	1	49	29	19	2	0
Emir Sultan	27	43	25	3	2	0
Yesil Mosque	8	38	22	19	11	2
The Grand Mosque	22	43	13	14	6	2
Yildirim Beyazid	17	46	26	10	1	0
Hudavendigar	27	57	3	9	1	3
Orhan Gazi	20	28	12	35	5	0
Alaaddin Pasa	34	52	12	1	1	0

Graph 5. The user perception of thermal comfort in winter.



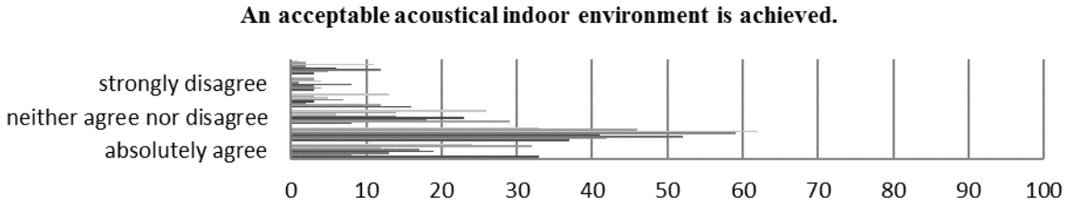
	absolutely agree	agree	neither agree nor disagree	disagree	strongly disagree	can't choose
Karaseyh	11	58	24	5	2	0
Emir Sultan	11	12	41	18	13	5
Yesil Mosque	3	38	23	22	6	8
The Grand Mosque	9	41	21	17	7	5
Yildirim Beyazid	3	47	10	27	10	3
Hudavendigar	17	20	29	19	11	4
Orhan Gazi	23	59	12	2	1	3
Alaaddin Pasa	20	27	46	7	1	2

Graph 6. The user perception of heating and air conditioning systems use



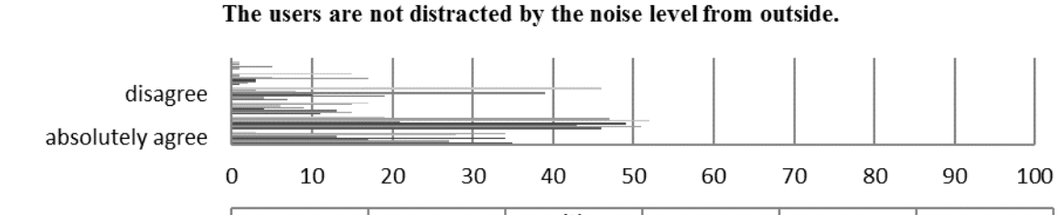
	absolutely agree	agree	neither agree nor disagree	disagree	strongly disagree	can't choose
Karaseyh	3	16	7	48	26	0
Emir Sultan	31	49	14	3	3	0
Yesil Mosque	20	53	7	13	7	0
The Grand Mosque	11	24	22	27	15	1
Yildirim Beyazid	37	36	4	13	10	0
Hudavendigar	22	57	10	5	3	3
Orhan Gazi	4	36	35	23	2	0
Alaaddin Pasa	29	47	14	7	2	1

Graph 7. The user perception of indoor noise level



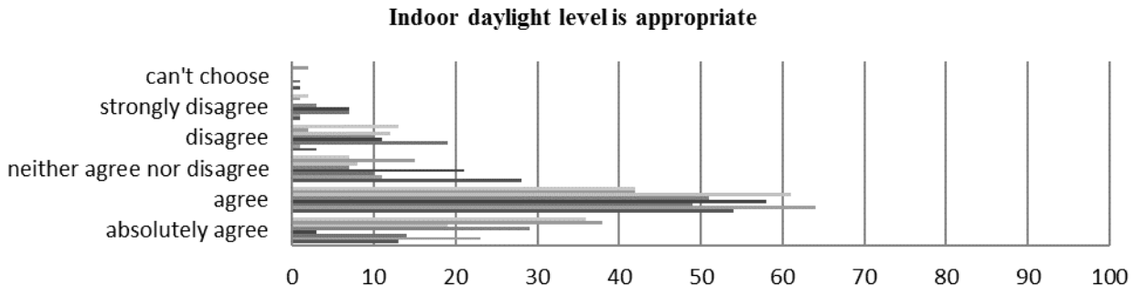
	absolutely agree	agree	neither agree nor disagree	disagree	strongly disagree	can't choose
Karaseyh	24	33	26	13	3	1
Emir Sultan	32	46	14	3	3	2
Yesil Mosque	12	62	6	5	4	11
The Grand Mosque	17	59	14	7	1	2
Yildirim Beyazid	19	41	23	3	8	6
Hudavendigar	13	52	18	2	3	12
Orhan Gazi	8	42	29	12	4	5
Alaaddin Pasa	33	37	8	16	3	3

Graph 8. The user perception of acoustical characteristics of mosque volume



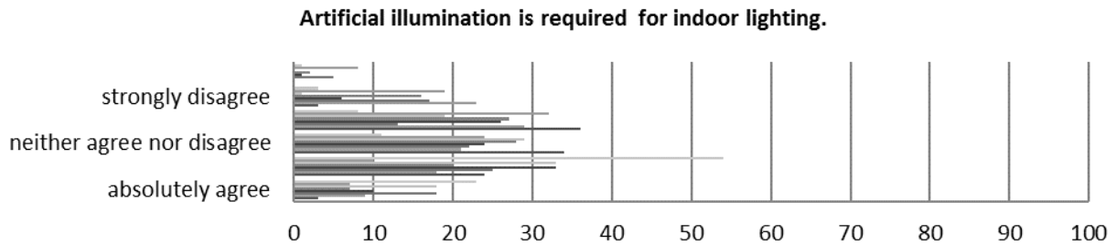
	absolutely agree	agree	neither agree nor disagree	disagree	strongly disagree	can't choose
Karaseyh	3	19	17	46	15	0
Emir Sultan	34	47	15	3	1	0
Yesil Mosque	28	52	6	8	5	1
The Grand Mosque	13	21	9	39	17	1
Yildirim Beyazid	34	49	4	10	3	0
Hudavendigar	17	43	13	19	3	5
Orhan Gazi	27	51	15	4	2	1
Alaaddin Pasa	35	46	11	7	1	0

Graph 9. The user perception of noise problem from outside



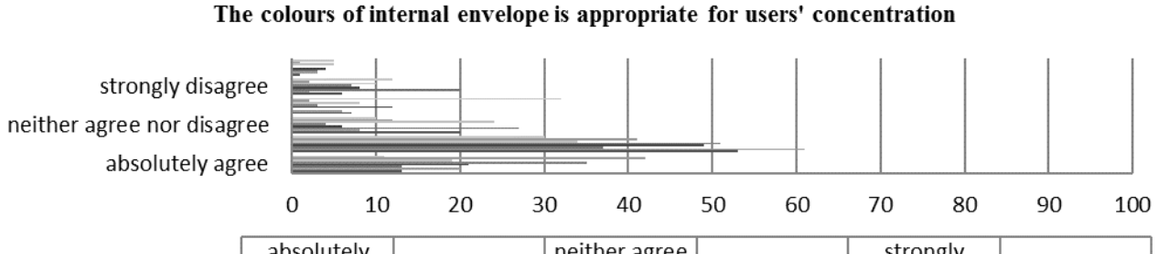
	absolutely agree	agree	neither agree nor disagree	disagree	strongly disagree	can't choose
Karaseyh	36	42	7	13	2	0
Emir Sultan	38	42	15	2	1	2
Yesil Mosque	19	61	8	12	0	0
The Grand Mosque	29	51	7	10	3	0
Yildirim Beyazid	3	58	21	11	7	0
Hudavendigar	14	49	10	19	7	1
Orhan Gazi	23	64	11	1	1	0
Alaaddin Pasa	13	54	28	3	1	1

Graph 10. The user perception of indoor natural lighting level in mosques.



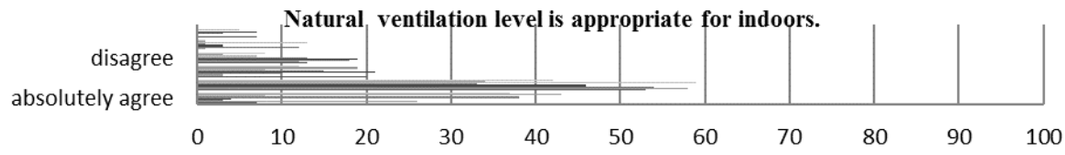
	absolutely agree	agree	neither agree nor disagree	disagree	strongly disagree	can't choose
Karaseyh	23	54	11	8	3	1
Emir Sultan	7	10	24	32	19	8
Yesil Mosque	18	33	29	19	1	0
The Grand Mosque	7	20	28	27	16	2
Yildirim Beyazid	10	33	24	26	6	1
Hudavendigar	18	25	22	13	17	5
Orhan Gazi	9	18	21	29	23	0
Alaaddin Pasa	3	24	34	36	3	0

Graph 11. The user perception of artificial light sources use in mosques



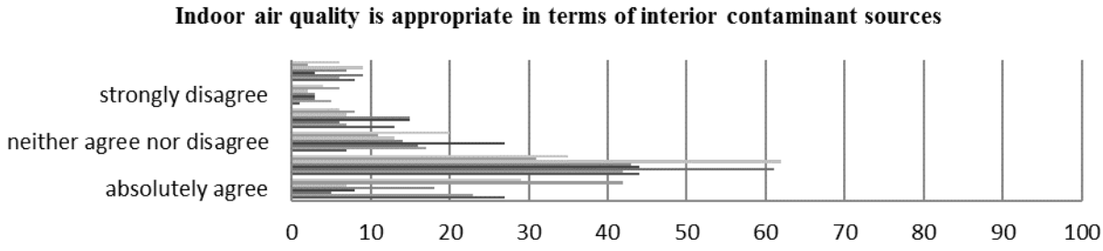
	absolutely agree	agree	neither agree nor disagree	disagree	strongly disagree	can't choose
Karaseyh	11	30	10	32	12	5
Emir Sultan	42	41	12	2	2	1
Yesil Mosque	19	34	24	8	10	5
The Grand Mosque	35	51	4	3	7	0
Yildirim Beyazid	21	49	6	12	8	4
Hudavendigar	13	37	27	0	20	3
Orhan Gazi	20	61	8	6	2	3
Alaaddin Pasa	13	53	20	7	6	1

Graph 12. The user perception of colour preference in mosques' internal envelope



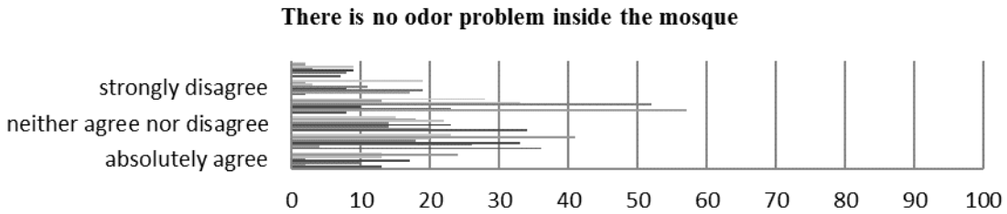
	absolutely agree	agree	neither agree nor disagree	disagree	strongly disagree	can't choose
Karaseyh	37	42	12	8	1	0
Emir Sultan	43	34	19	3	1	0
Yesil Mosque	8	59	8	7	13	5
The Grand Mosque	38	33	15	13	1	0
Yildirim Beyazid	4	46	21	19	3	7
Hudavendigar	3	54	10	18	12	3
Orhan Gazi	26	58	3	12	1	0
Alaaddin Pasa	7	53	20	13	0	7

Graph 13. The user perception of natural ventilation in mosques



	absolutely agree	agree	neither agree nor disagree	disagree	strongly disagree	can't choose
Karaseyh	29	35	20	6	4	6
Emir Sultan	42	31	11	8	6	2
Yesil Mosque	7	62	13	7	2	9
The Grand Mosque	18	43	14	15	3	7
Yildirim Beyazid	8	44	27	15	3	3
Hudavendigar	5	61	16	6	3	9
Orhan Gazi	23	42	17	7	5	6
Alaaddin Pasa	27	44	7	13	1	8

Graph 14. The user perception of indoor air quality in terms of interior contaminant sources in mosques



	absolutely agree	agree	neither agree nor disagree	disagree	strongly disagree	can't choose
Karaseyh	13	23	15	28	19	2
Emir Sultan	24	41	18	13	2	2
Yesil Mosque	13	20	22	33	3	9
The Grand Mosque	2	18	14	52	11	3
Yildirim Beyazid	17	33	23	10	8	9
Hudavendigar	10	26	14	23	19	8
Orhan Gazi	2	4	20	57	17	0
Alaaddin Pasa	13	36	34	8	2	7

Graph 15. The user perception of odor problem in mosques

Table 1. Status of user satisfaction

COMFORT CONDITIONS		OVERALL EVALUATIONS							
		Alaaddin Pasa	*Orhan Gazi*	*Hudavendigar*	*Yıldırım Beyazıd*	*Grand Mosque*	*Green Mosque*	*Emir Sultan*	*Karaseyh*
		S D	S D	S D	S D	S D	S D	S D	S D
Thermal Comfort	Indoor air temperature in summer	+89	+9	+78	+107	+92	+56	+11	+31
	Indoor air temperature in witer	+117	+23	+100	+68	+61	+13	+90	+28
	Mechanical heating/AC use	**-58**	**-101**	**-13**	**-6**	**-28**	**-10**	+10	**-71**
Acoustical Comfort	Indoor Noise Problem	+94	+17	+90	+77	**- 11**	+66	+102	**- 78**
	Volume Acoustics	+81	+38	+70	+60	+84	+73	+101	+62
	Outdoor Noise Problem	+107	+97	+52	+101	**-26**	+90	+110	**-51**
Visual Comfort	Daylight	+75	+107	+44	+39	+93	+87	+114	+97
	Artificial Light	+12	+39	**-14**	**-15**	+25	**-48**	+46	**-86**
	Colour Preferance	+60	+91	+23	+63	+104	+44	+119	**-4**
Indoor Air Quality	Natural Ventilation	+54	+96	+18	+29	+94	+42	+115	+106
	Interior Contaminant Sources	+83	+71	+59	+39	+58	+65	+95	+79
	Indoor Odor Problem	+50	**-83**	**-15**	+41	**-52**	+7	+72	**-17**