

USER SATISFACTION ASSESMENT OF INDOOR ENVIRONMENTAL QUALITY IN TODAY'S MOSQUES: THE CASE OF NILUFER, BURSA ¹

GÜNÜMÜZ CAMİLERİNDE İÇ ÇEVRE KALİTESİNİN KULLANICI MEMNUNİYETİ AÇISINDAN DEĞERLENDİRİLMESİ: BURSA NİLÜFER ÖRNEĞİ

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Öz: Amaç: Bu araştırmanın amacı, günümüz camilerinde iç çevre kalitesine dair kullanıcı algısının termal konfor, akustik konfor, görsel konfor ve iç mekan hava kalitesi konularına odaklanarak araştırılmasıdır. Çalışma literatür taraması, kullanıcı memnuniyeti anketinin değerlendirilmesi ve araştırma bulgularının tartışılması olarak üç ana bölümden oluşmaktadır. **Yöntem:** Bursa'nın Nilüfer ilçesinde yer alan ve son otuz yılda inşa edilen on caminin kullanıcılarına iç çevre kalitesi parametrelerini konu alan bir kullanıcı memnuniyet anketi uygulanmıştır. Anket verilerine bağlı olarak, her caminin kullanıcı memnuniyet düzeyi 5'li Likert ölçeğine göre puanlandırılmıştır. **Bulgular:** Yapma çevredeki iç mekân konfor koşulları ibadet esnasında kullanıcıları fiziksel performansı üzerinde doğrudan etkilidir. Araştırma bulguları bölümünde incelenen konfor parametreleri tablolar halinde sunulmaktadır. Anket sonuçları, bir camideki iç hava kalitesi ve görsel konforla ilgili olumsuz görüşlerin dışında, on caminin tümünde kullanıcıların konfor algısının olumlu yönde olduğunu göstermektedir. **Sonuç:** İç mekân ile kullanıcılar arasındaki etkileşimi gösteren araştırma bulguları, kullanıcıların refahı ve konforu için sağlanması gereken termal, görsel ve işitsel parametreler göz önüne alınarak yeni camilerin tasarım sürecine aktarılabileceği düşünülmektedir.

Anahtar Kelimeler: Cami, İç Çevre Kalitesi, Konfor, Kullanıcı Memnuniyeti

Abstract:Aim: The objective of this research paper is to investigate users' perception of indoor environmental quality in present-day mosques, focusing on thermal comfort, acoustical comfort, visual comfort and indoor air quality. The study consists of three main parts: literature review, evaluation of user satisfaction survey, and discussion of the research findings. **Method:** A user's satisfaction survey was conducted to ten mosques' users built in the last three decades in Nilufer district, inBursa. The questionnaires were applied to users subjecting indoor comfort parameters of the mosques. In accordance with the survey data, the level of user satisfaction is scored using a 5-point Likert scale for each mosque. **Results:** The users' physical performances during worhsip are directly related to the indoor comfort conditions provided in the built environment. In the research findings part, investigated comfort parametersof the survey are presented in tables. Survey results show that the perceptions of comfort for all ten mosques can be considered to be positive, except negative views relating to indoor air quality and visual discomfort in one mosque. **Conclusion:** The research findings of the interaction between the indoor environment and users can be transferred into the design process of new mosques considering thermal, visual, auditory parameters required for occupant's well-being and comfort.

Key Words: Mosque, Indoor Environmental Quality, Comfort, User Satisfaction

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INTRODUCTION

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. Worshippers 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.

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 by the American Society of Heating, Refrigeration and Air Conditioning Engineers Standard 55 (ANSI/ASHRAE, 1992) and The International Organization for Standardization ISO EN 7730 standards (1994).

The objective of this research paper is to investigate the user perception of indoor envi-

ronmental quality in today's mosques through case studies. In this context, selected ten mosques in Bursa Nilufer district were evaluated based on the user requirements and the determinants of indoor comfort conditions including thermal, visual, acoustical comfort and indoor air quality aspects. Prior to the field work, the architectural features of case buildings are studied, together with the literature review on the user comfort in religious structures, particularly in mosques. Such research papers subjecting user comfort in mosques were conducted either as questionnaire surveys or computer simulations and experimental analysis of building elements in-situ. Saeed (1996: 17-21) aimed to measure the level of thermal comfort and evaluate user's satisfaction in the dry desert region of Saudi Arabia. Al-ajmi (2010: 2407-2413) performed an investigation on indoor environmental conditions of mosques in dry desert climate of Kuwait by physical measurements and subjective questionnaires. Al-Homoud, et al. (2009: 607-614) assessed thermal comfort of occupants while monitoring the case building's energy consumption in Saudi Arabia.

Budaiwi and Abdou (2013: 37-50) later identified potential energy savings of heating, ventilation and air conditioning (HVAC) system operational strategies and the impact of envelope insulation in mosques. Abdul Hameed (2011: 249-264) evaluated the thermal



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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: 139-147) 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: 1-19) 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, facilities, physical protection of structures and costs are reviewed as; Das, et. all (2012: 01-08), Sadana (2015: 171-176), Açıcı (2017: 275-288), Korkmaz and Alacahan (2014: 1-23).

Today, many investigations are carried out worldwide to improve comfort levels of occupants; however a limited number of studies have dealt with comfortable indoor climate in mosques. Compared to research studies on other building typologies, user requirements and environmental comfort studies in 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 in Turkey.

METHODOLOGY

The user perception of the indoor environmental quality can be examined from the responses of the user surveys. From this point of view, a fieldwork 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 30 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 paper is limited to indoor comfort perception of mosque users.

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



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acquired by 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 tables in the research findings section.

CASE STUDY: PRESENT-DAY MOSQUES IN BURSA, TURKEY

Bursa with a population of 2.5 million is the 4th most populated metropolitan city in Turkey. It is located between the south-east coast 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 in November 2015, during the heating season.

Turkish Presidency of Religious Affairs classified the mosques in five categories, from A to E according to their capacity and service features. A class mosques are the historical and symbol mosques of Bursa recognized at country level. B class mosques are stated to have importance for service in the region, province or district where they are located. Interviews were held in “C and D” category mosques. Medium size C class mosques are located in the province, district or town centers. Religious staff is employed in C class mosques and they are open to worship at all hours of the day. D class mosques are small scale mosques with a minor congregation¹¹. The basic features of the selected mosques in Nilufer district are given in Table 1.

1 <http://www.resmigazete.gov.tr/main.aspx?home>



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Table 1. The Basic Features of the Case Studies in Bursa²¹

Case Study Building	Opened to Worship	Service Group	Area of Worship	Capacity
Eyup Yıldız Mosque	1996	D	264 m ²	350
U.U. Campus Mosque	1997	C	2500 m ²	4500
Small Industry Zone Mosque	1988	C	1085 m ²	1500
Omer Kaya Merve Mosque	2005	C	700 m ²	1500
Altınşehir Mosque	2006	C	1050 m ²	2000
Fatih Sultan Mehmet Mosque	2007	C	1230 m ²	2500
Haci Omer Raca Mosque	2008	C	670 m ²	1200
Besevler - Safa Mosque	2011	C	400 m ²	800
Ali Riza Inak Mosque	2012	C	1000 m ²	1700
Barla Mosque	2013	C	600 m ²	1000

² <http://www.resmigazete.gov.tr/main.aspx?home>

Indoor comfort parameters and user perception of indoor comfort conditions for historical mosques in Bursa was covered in the first part of this study (Sezer and Kaymaz, 2016: 43-54). Historical mosques with a cultural heritage value are mainly located in the old trade center and most of them are dating from the early Ottoman Period of the 14th and 15th century. Later design mosques (1988 – 2013)

were investigated in this paper. Case buildings are located in Nilüfer district, which is one of the newly structured counties of Bursa. The basic architectural features of ten mosques are briefly described below according to the year of construction. In Figure 1, case study locations are marked on the aerial photograph³².

³ <https://earth.google.com/web/>

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Figure 1. Location of the Case Buildings: 1)Eyup Yıldız Mosque, 2)Uludag University Campus Mosque, 3)Bursa Small Industry-Zone Mosque, 4)Merve Mosque, 5)Altınşehir Mosque, 6)FSM Mosque, 7)Hacı Omer Raca Mosque, 8)Safa Mosque 9) Ali Rıza İnâk Mosque 10) Barla Mosque²

The reinforced concrete (RC) mosques have generally square or rectangular plans. The main facades are mainly oriented to south-east, towards Mecca which enhances the directionality of the prayer space. These mosques are planned to serve the local community with different peak

capacities. The courtyards are also used to accommodate community during the prayers. The women's prayer hall is generally separated, typically relegated to the rear mezzanine level or in closed rooms altogether. The selected mosques are naturally ventilated and illuminated through window openings. Day-

light is supported by pendant light fittings. Lamps, along with other furnishings like carpets, form a significant aspect of mosque architecture. For climate control, the mosques are equipped with mechanical systems such as underfloor heating and standalone air conditioners in the main prayer hall.

Eyup Yıldız Mosque: The building is designed as a part of a fuel station on Bursa - Izmir highway. The mosque has an almost square plan. As seen in Figure 2, organic form timber roof is coated with lead and slate. Marble is used for the interior decoration and cladding of the non-bearing walls. The building

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is naturally ventilated and illuminated from the glazed roof eaves. Timber framed corner windows on the ground level enable to see the outside and allow sunlight to penetrate the

prayer hall. Underfloor heating is provided for winter use. Ablution facilities are located on the basement floor.



Figure 2. Images from the Outside and Inside of Eyup Yildiz Mosque

Uludag University Campus Mosque: The building is located in the center of Uludag University Gorukle campus area. The two storey square mosque is designed without minaret and courtyard. Pyramid shaped roof covers main the prayer hall. The interior is white

and very simply decorated that makes the indoor environment more clear and bright. The building is naturally ventilated and illuminated by narrow PVC windows. Standalone air conditioners installed for space heating and cooling (Figure 3).



Figure 3. Images from the Outside and Inside of Uludag University Campus Mosque

Small Industry Zone Mosque: This project is located in Nilufer small industrial zone. Two-storey mosque has a rectangular plan with two minarets (Figure 4). A free standing ablution fountain, and toilets locate in the

landscaped green courtyard. The mosque is naturally ventilated. Arcades are roofed with barrel vaults and the external envelope is glazed with arched windows providing sunlight during the day.

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Figure 4. Images from the Outside and Inside of Bursa Small Industry-Zone Mosque

Omer Kaya - Merve Mosque: Linked by a series of landscaped terraces from the main high road, the mosque is situated on an elevated land slope in Ataevler residential neighborhood, in Figure 5. It is adjoined to an open courtyard with 2800 m² green area.

The circular opening in the drum of the dome and external walls are installed with window openings, so the interior space is naturally illuminated from different spots. The building is naturally ventilated. Underfloor heating system is provided.



Figure 5. Images from the Outside and Inside of Omer Kaya -Merve Mosque

Hacı Fahreddin Kilinc - Altınşehir Mosque: The religious building is located on a low-slopped residential zone in Altınşehir (Figure 6). Two minarets are located on both sides of the main entrance. Transparent openings

on the outer facades and in the drum of the dome form an illumination composition for the inner spaces. Underfloor heating system is provided for winter use.

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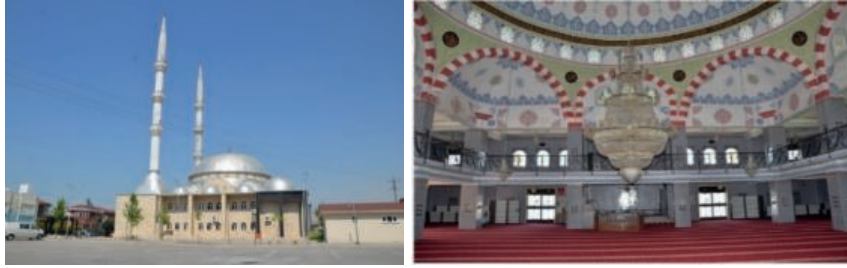


Figure 6. Images from the Outside and Inside of Altınşehir Mosque

Fatih Sultan Mehmet Mosque: The project in Figure 7 is located on one of the main boulevards in Nilüfer district. The main prayer hall reflects the central dome mosque typology. The external envelope is clad with

marble panels. A line of operable windows on the side walls and fixed perforated window openings in the drum of the dome is designed to allow daylight to filter into the inner space. Underfloor heating is provided.



Figure 7. Images from the Outside and Inside of Fatih Sultan Mehmet Mosque

Hacı Omer Raca Mosque: The mosque is located in Ozlucé residential area, in Nilüfer district. The building is placed on a courtyard with visible entrances at each side. The courtyard contains carpark, an ablutions fountain

and restroom facilities. The mosque's interior is carpeted, naturally ventilated and illuminated by the arched windows rising to the upper level of walls. Standalone air conditioners were installed for space heating and cooling.

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Figure 8. Images from the Outside and Inside of Hacı Omer Raca Mosque

Besevler - Safa Mosque: This project is located in Besevler residential area, in Nilüfer district. The prayer space is shielded from the outdoor conditions by the barrel vault roof, as seen in Figure 9. Interior space can be natu-

rally illuminated and ventilated through a sliding skylight in the barrel vault. Besides the sky light, the walls are drilled with the rectangular and arched openings of different sizes to ensure the light to stream in during the day.



Figure 9. Images from the Outside and Inside of Besevler - Safa Mosque

Ali Rıza İnâk Mosque: The mosque is located in Gorukle residential area, in Nilüfer district. The main prayer hall is covered with a central dome surrounded by barrel vaults. Indoors are lit by the windows on the outer facades. Two minarets free from the structure

rise up on the sides of the foyer. Ablutions fountain and restrooms are located in the courtyard. Solar water heating system in the courtyard is used to obtain warm domestic water for the mosque's congregation.

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Figure 10. Images from the Outside and Inside of Ali Rıza İnâk Mosque

Barla Mosque: This project is located in Ertugrul residential area, in Nilufer district. The building is designed as a replica of 19th century Ottoman neo-baroque Buyuk Mecidiye Mosque, known as Ortaköy Mosque. Sets of

arched windows pierced into the side walls of ground and the mezzanine floor provide sunlight for the main hall. Ablution area, toilets and lockers are located in the courtyard. Underfloor heating is provided.



Figure 11. Images from the Outside and Inside of Barla Mosque

RESEARCH FINDINGS

In the first section three questions were asked, mainly consisting of the respondent's socio-demographic information. Gender, age, educational status of respondents are given below respectively. Out of total 1000 participants, 17% of respondents are women and 83% are men which shows that the majority of the respondents are men. Survey results

show that, 6% of the respondents are below the age of 18, 28% are between 19-25 years old, 29% are between 26-45 years old, 25% are between 46-65 years old and 12% of the respondents are above the age of 65. 29% of respondents report to have bachelor's degrees; 24% have high school education and an additional 22% graduated from vocational school; 25% have only secondary school edu-



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cation or less. The results reveals that there is a diversity in terms of education among the users who participated in the questionnaire.

The second part of the survey includes the user perception of comfort conditions in selected mosques. The responses for 12 questions are illustrated in tables below. The answers reflect the impact of the current comfort conditions on user's perception particularly for indoors. First three questions of the inter-

view are about thermal comfort conditions in mosques. The users were asked to express how they feel about the indoor temperature during winter and summer seasons. Table 2 shows the responses for summer, while the answers in Table 3 reflect the indoor thermal perception in winter. Table 4 shows the users perception of the mechanical heating and air conditioning system use providing appropriate climate for indoors.

Table 2. Survey Responses for “The Indoor Temperature is Appropriate During Summer”

	E y u p Yildiz	U.U. Campus	Kucuk sanayi	Merve	Altin sehir	FSM	Ömer Raca	Safa	A l i Riza	Barla
absolutely agree	18	14	13	18	14	10	9	13	11	10
agree	21	21	37	27	38	57	22	32	51	37
neither agree nor disagree	26	35	23	13	17	13	39	18	12	29
disagree	20	13	13	22	12	12	11	13	11	13
strongly disagree	12	8	7	9	10	6	9	10	9	4
can't choose	3	9	7	11	9	2	10	14	6	7



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Table 3. Survey Responses for “The Indoor Temperature is Appropriate During Winter”

	Eyup Yildiz	U.U. Campus	Kucuk sanayi	Merve	Altin sehir	FSM	Ömer Raca	Safa	Ali Riza	Barla
absolutely agree	10	19	19	16	18	21	20	12	16	13
agree	31	28	22	27	46	42	32	31	45	62
neither agree nor disagree	18	31	25	11	10	18	24	20	21	12
disagree	11	16	19	24	15	9	10	16	9	7
strongly disagree	13	4	9	14	9	7	8	12	6	2
can't choose	17	2	6	8	2	3	6	9	3	4

Table 4. Survey Responses for “The Use of Mechanical Climatisation Equipment is Appropriate During Summer and Winter”

	Eyup Yildiz	U.U. Campus	Kucuk sanayi	Merve	Altin sehir	FSM	Ömer Raca	Safa	Ali Riza	Barla
absolutely agree	22	24	19	12	10	16	11	12	13	17
agree	23	28	27	28	31	42	21	28	22	26
neither agree nor disagree	17	21	20	31	29	17	26	21	37	12
disagree	19	11	18	14	17	13	23	18	13	18
strongly disagree	9	7	5	12	4	6	5	6	9	10
can't choose	10	11	11	3	9	6	14	15	6	17

The following questions aim to cover acoustical comfort perception of users in terms of acoustical characteristics of mosque volume

and sources of noise from indoors and outdoors, presented accordingly in Table 5, Table 6, and Table 7.



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Table 5. Survey Responses for “The Users are not Distracted by the Interior Surrounding Noise Level”

	Eyup Yildiz	U.U. Campus	Kucuk sanayi	Merve	Altin sehir	FSM	Ömer Raca	Safa	Ali Riza	Barla
absolutely agree	27	17	30	16	21	17	10	18	15	13
agree	46	31	32	19	36	45	38	37	41	53
neither agree nor disagree	7	41	13	26	22	19	21	16	17	13
disagree	7	5	16	12	10	8	19	13	10	12
strongly disagree	10	4	6	14	7	5	11	9	7	6
can't choose	3	2	3	13	4	6	1	7	10	3

Table 6. Survey Responses for “An Acceptable Acoustical Indoor Environment is Achieved”

	Eyup Yildiz	U.U. Campus	Kucuk sanayi	Merve	Altin sehir	FSM	Ömer Raca	Safa	Ali Riza	Barla
absolutely agree	27	13	17	11	34	25	21	12	10	17
agree	48	21	42	27	24	34	32	51	49	40
neither agree nor disagree	10	42	15	24	21	15	23	12	13	19
disagree	8	11	13	18	12	9	14	8	21	14
strongly disagree	4	7	8	11	5	7	8	6	4	3
can't choose	3	6	3	9	4	10	2	11	3	7



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Table 7. Survey Responses for “The Users are not Distracted by the Noise Level from Outside”

	Eyup Yildiz	U.U. Campus	Kucuk sanayi	Merve	Altin sehir	FSM	Ömer Raca	Safa	Ali Riza	Barla
absolutely agree	27	8	27	25	19	18	15	27	15	10
agree	30	27	35	31	36	45	25	44	41	57
neither agree nor disagree	12	38	18	20	24	19	21	11	22	12
disagree	8	15	10	14	17	10	23	9	13	9
strongly disagree	6	10	7	8	2	5	12	7	5	4
can't choose	17	2	3	2	1	3	4	2	4	8

The users' perception of visual comfort for the existing conditions in mosques' prayer halls are illustrated in the tables below. Table 8 provides data for daylight use in mosques

while Table 9 reflects the user views on artificial illumination. Table 10 shows the users' opinion regarding the color selection in mosques' interiors.

Table 8. Survey Responses for “Indoor Daylight Level is Appropriate”

	Eyup Yildiz	U.U. Campus	Kucuk sanayi	Merve	Altin sehir	FSM	Ömer Raca	Safa	Ali Riza	Barla
absolutely agree	11	8	13	36	21	22	17	14	24	23
agree	52	19	54	24	36	46	28	48	54	44
neither agree nor disagree	21	30	10	6	16	13	23	14	12	10
disagree	7	21	3	15	11	9	18	12	4	3
strongly disagree	3	17	3	11	4	4	9	8	3	12
can't choose	6	5	17	8	12	6	5	4	3	8



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Table 9. Survey Responses for “Artificial Illumination is Required for Indoor Lighting”

	Eyup Yildiz	U.U. Campus	Kucuk sanayi	Merve	Altin sehir	FSM	Ömer Raca	Safa	Ali Riza	Barla
absolutely agree	5	26	10	8	6	9	12	2	6	6
agree	22	37	11	12	13	15	17	20	25	18
neither agree nor disagree	20	14	12	15	25	20	25	24	24	17
disagree	37	12	41	22	27	28	26	34	21	38
strongly disagree	8	9	14	36	19	23	11	17	18	13
can't choose	8	2	12	7	10	5	9	3	6	8

Table 10. Survey Responses for “The Indoor Color Selection is Appropriate for Users’ Concentration”

	Eyup Yildiz	U.U. Campus	Kucuk sanayi	Merve	Altin sehir	FSM	Ömer Raca	Safa	Ali Riza	Barla
absolutely agree	18	10	17	21	9	13	16	18	7	11
agree	14	18	20	27	28	29	34	22	31	20
neither agree nor disagree	34	26	26	29	26	30	21	17	28	16
disagree	8	28	18	11	19	15	19	19	13	9
strongly disagree	6	14	11	7	10	7	8	12	7	28
can't choose	19	4	8	5	8	6	2	12	14	16

The responses for natural ventilation based on outdoor air flow, the indoor air quality and

odor problem are illustrated in the Table 11, Table 12 and Table 13 respectively.



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Table 11. Survey Responses for “Natural Ventilation Level is Appropriate for Indoors”

	Eyup Yildiz	U.U. Campus	Kucuk sanayi	Merve	Altin sehir	FSM	Ömer Raca	Safa	Ali Rıza	Barla
absolutely agree	10	9	20	29	21	17	15	7	8	29
agree	57	18	26	32	36	43	24	46	41	38
neither agree nor disagree	17	33	21	18	15	18	37	14	9	11
disagree	11	28	19	11	8	12	15	13	24	8
strongly disagree	2	11	12	4	3	6	7	9	6	4
can't choose	3	1	2	6	17	4	2	11	12	10

Table 12. Survey Responses for “Indoor Air Quality is Appropriate in terms of Interior Contaminant Sources”

	Eyup Yildiz	U.U. Campus	Kucuk sanayi	Merve	Altin sehir	FSM	Ömer Raca	Safa	Ali Rıza	Barla
absolutely agree	19	9	16	18	13	13	10	11	23	14
agree	53	16	35	26	31	44	26	35	30	56
neither agree nor disagree	10	22	17	31	12	19	33	23	21	12
disagree	9	34	16	14	19	9	21	14	11	8
strongly disagree	3	16	4	9	12	6	8	7	7	7
can't choose	6	2	12	2	13	9	2	10	8	3



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Table 13. Survey Responses for “There is No Odor Problem Inside the Mosque”

	Eyup Yildiz	U.U. Campus	Kucuk sanayi	Merve	Altin sehir	FSM	Ömer Raca	Safa	Ali Riza	Barla
absolutely agree	21	10	13	11	9	16	14	18	16	7
agree	26	12	30	28	34	32	22	19	21	17
neither agree nor disagree	12	15	19	38	25	30	27	25	21	42
disagree	17	32	16	12	14	6	19	21	24	19
strongly disagree	14	26	14	7	8	9	12	9	11	4
can't choose	10	5	8	4	9	7	6	8	7	11

The comfort perception of respondents in case studies were obtained for thermal environment, lighting, acoustic and indoor air quality issues in tables above. In accordance with the survey data, the level of comfort score was voted within -2 and +2. Negative

scores indicate user's dissatisfaction (total minimum -100 points) and marked with bold characters while positive scores indicate user satisfaction (total maximum +100 points). The overall evaluations of ten case studies are summarized below in Table 14.



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Table 14. Status of User Satisfaction

COMFORT CONDITIONS		OVERALL EVALUATIONS									
		<i>Eyüp Yıldız</i>	<i>U.U. Campus</i>	<i>Small Industry</i>	<i>Merve</i>	<i>Altın şehir</i>	<i>FSM</i>	<i>Omer Raca</i>	<i>Safa</i>	<i>Ali Rıza</i>	<i>Barla</i>
		S D	S D	S D	S D	S D	S D	S D	S D	S D	S D
Thermal Comfort	Indoor air T°C in summer	13	20	36	23	34	53	11	25	44	36
	Indoor air T°C in winter	14	42	23	7	49	61	46	15	56	77
	Heating & AC use	30	51	37	14	26	49	10	22	17	22
Acoustical Comfort	Indoor Noise	73	52	64	11	54	61	17	42	47	55
	Volume Acoustics	86	22	47	9	70	54	44	55	40	54
	Outdoor Noise	64	8	65	51	53	61	8	75	48	60
Visual Comfort	Daylight	61	-20	71	59	59	73	26	48	92	63
	Artificial Light	21	-59	38	66	40	41	7	44	20	34
	Indoor Color	30	-18	14	44	7	26	31	15	18	-23
Indoor Air Quality (IAQ)	Natural Ventilation	62	-14	23	71	64	53	25	29	21	80
	Air Quality	76	-32	43	30	14	49	9	29	51	62
	Odor Problem	23	-52	12	24	22	40	7	16	7	4

S: Satisfied, D: Dissatisfied (very satisfied +2, satisfied +1, neither satisfied nor dissatisfied 0, dissatisfied -1, very dissatisfied -2, can't choose 0)

Thermal Comfort

According ASHRAE Standard 55, thermal comfort is defined as “The state of mind which expresses satisfaction with the thermal environment” (ANSI/ASHRAE, 1992). Thermal



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environmental conditions are 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 (ISO EN 7730, 1994). Indoor temperature and relative humidity are the leading factors for indoor thermal comfort.

In all ten mosques, electrical or fuel based mechanical heating is provided. In most case buildings underfloor heating pipes were installed for winter use. For the gathering units like main prayer halls, standalone air conditioners are also used for space heating as well as cooling. According to the survey results, the users of all mosques are content with the interior air temperature in winter and summer as well as mechanical system use for heating and air conditioning. The results can also be attributed to the intermittent and short operating schedule of the religious buildings.

Acoustical Comfort

The acoustical comfort conditions are perceived to be satisfactory in all case studies. Sound systems by means of wall mount and ceiling speakers are placed for prayer leader to address the congregation. Few complaints are

reported about environmental noise generated from outdoor sources that cause disturbance to worshipper's concentration. For Eyup Yıldız Mosque on the highway, rush hours negatively impact the acoustical comfort. The survey was conducted mainly in the residential areas; therefore, a noise disturbance does not occur except motorize equipment use in the building and road construction sites.

Visual Comfort

Indoor daylight and artificial illumination level along with the interior colors are discussed as the preconditions of visual comfort. The selected mosques are illuminated through sets of windows pierced into the side walls of ground and the mezzanine floors. Perforations throughout the facades and domes also enable a visual transparency, allowing diffuse daylight to flood into the interior of mosques. Daylight is supported by pendant light fittings.

According to the users' thoughts about indoor illumination of case studies, it has been seen that almost all the users are content with daylight level except U.U. Campus Mosque due to its low facade transparency ratio. Visual discomfort also occurs based on inadequate artificial sources and illumination level in the same mosque.

The surface property and the color characteristics of the internal envelope affect the users'



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visual comfort. The interior walls of mosques are predominantly light colored. Mainly green or red carpets are preferred on the prayer floor. Most of the users stated that the interior color choice is appropriate for users' concentration except U.U. Campus and Barla Mosque.

Indoor Air Quality (IAQ)

In ASHRAE Standard 62 (ANSI/ASHRAE, 2001) guidelines, moisture in building assemblies, poor 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 the congregation five times during the day and for Friday prayers. The selected mosques are naturally ventilated. U.U. Campus Mosque users expressed that the conditions under they worship are not satisfactory in terms of natural ventilation, air quality and indoor odor problem. Therefore, IAQ seems to be one of the leading problems in this mosque. Besides improving the quality and hygiene of carpeting, air circulation should be provided in prayer halls taking into account of peak occupancy hours and actual capacity of mosques given that interior contaminant sources and harmful micro-organisms can emerge in such public places.

CONCLUSIONS

The mosque, constituting an urban room for the Muslim community, creates and nourishes everyday life around it. Today's mosques in the case studies aim to preserve the tradition in terms of architecture elements. It has resulted in a trend of constructing centrally-planned buildings with domes, arched windows, courtyards and minarets similar to the existing historical mosques but with RC framework, thinner and lighter masonry units. On the other hand, the mosques are equipped with mechanical heating and AC systems for climate control.

Physical and psychological well-being and tranquility of the users influenced by the indoor comfort conditions provided in the built environment. This subjective comfort study aims to clarify the physical environment matters to achieve satisfactory indoor conditions in mosques by interviewing with the users. Survey results show that comfort perceptions for all ten mosques can be considered to be positive. On the other hand, the findings indicated some discomfort issues related to IAQ and illumination for one mosque. The results should be further supported by objective studies such as building performance simulations and experimental measurements in order to analytically determine and interpret comfort conditions in mosques.



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