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A STUDY ON MEASURING PEDESTRIAN COMFORT LEVEL IN ISTANBUL KADIKÖY CITY CENTER

Pınar ÖZYILMAZ KÜÇÜKYAĞCI

Gebze Technical University, Faculty of Architecture, Department of City and Regional Planning
email:pozyilmaz@gtu.edu.tr, Kocaeli/Turkey (Corresponding Author)

Özgün ARIN

Okan Üniversitesi Faculty of Art, Design and Architecture, Department of Urban and Landscape Design, İstanbul/Turkey

ABSTRACT

This study is to measure the level of pedestrian comfort level in an urban area. The level of pedestrian comfort was measured by conducting a study in the selected area where Istanbul's Kadıköy district is located and its connected roads. Firstly, an inventory of the area was made by examining the current state of the area, its location, the historical development of the area. literature study and field analysis work were done. These analyzes include; morphological analyzes (sunbathing, dust / noise / wind), transportation (pedestrian and vehicle), open space/green spaces analysis, reinforcement analysis (barriers, lighting, other equipment) and image analysis. In addition to these analyzes, pedestrian counts were made at peak hours, weekdays and weekends, at various points to measure pedestrian comfort level. Pedestrian comfort level, pedestrian service level, pedestrian density level values were reached from pedestrian counts and physical and morphological values of area. Pedestrian comfort level analysis was conducted in two step. First step is pedestrian service level that is measured with pedestrian counts and other step of analysis is pedestrian comfort level that depends on current physical conditions of area. Service Level and Comfort level is between A to E level (Ocakçı, 2010). The result of comfort level of Bahariye Street is E level, Sakız Gülü is D level.

Key Words: Pedestrian Comfort Level, Pedestrian, Pedestrian Service Level

1. INTRODUCTION

Rapid urbanization in urban areas, unplanned urban fabric, increased roads, reduced abandoned areas for pedestrian affects seriously the pedestrian comfort level. The change of these physical conditions reduces the mobility and quality of the pedestrians while it has trapped them in the density of urbanites and vehicles. The concept, which is defined as a pedestrian way in the literature, leaves the place to the remaining areas from the roads and building areas, especially to the narrow pavements in dense urban textures. However, pedestrian spaces affected by physical conditions are included in urban design guidelines and regulations as standards, dimensions, pedestrian access distance. Especially, the location selection of structural elements in urban areas is also determined by the distance of pedestrian access.

The individual movement of the user in the city is directly related to the structural texture in the city, the use of land, the physical conditions and the individual's perception of the place (Kürkçüoğlu ve Ocakçı, 2015). The individual movement of the user in the city is directly related to the structural texture of the city, the land use, the physical conditions and the individual's perception of the place. Point-to-point connections such as vehicles, public transportation, parking, the right material selection, and compliance with certain standards are the most important criteria in the design of pedestrian zones to provide safe, comfortable mobility, to accommodate different functions, to increase accessibility (Birişci et.al.2002). Creating a comfortable space for the user to move and walk is a requirement for pedestrian zones (Ocakçı, 2010).

Safety, security, convenience and comfort, continuity, system coherence and attractiveness are required so that the trails can be relaxed and you can walk (Sarkar, 1993). According to Sarkar (2013), A level is as have the highest level of service that is required is required 6-meter width road and motorized vehicles, nonmotorized transportation and pedestrian -vehicle routes must be separated from each other. The other requirement is paths should carry comfort features that can serve all users as disabled, elderly people. The presence of pedestrian spaces in areas with different functions also provides different qualities and different levels of service. This was mentioned in the report that was prepared by Transport for London (2010). In this report, the pedestrian comfort level was measured according to function of areas as high streets, residential areas, office and retails, touristic areas, transport interchange areas. Different parameters are used in the literature to measure pedestrian comfort level in different sources. The level of comfort depends not only on the physical parameters but also on the natural qualities of the area or climatic conditions. Wind, sun, humidity and temperature as climatic conditions is also important for pedestrians. These climatic conditions affect the psychological comfort level of pedestrian. There are two comfort level as physical and psychological (Sarkar, 2013). Walking speed, participation to pedestrian activities, noise and pollution are the parameters of psychological comfort level. According to Gallin (2011), physical factors, location factors and user's factors affects the level of service. Design factors as path width, surface quality, obstructions on road, crossings, support facilities; location factors as connectivity, path environment, potential for vehicle conflict; users factor as pedestrian volume, mix of path users and personal security are calculated by measurements. Jaskiewicz (2000) measured the comfort level with nine parameters as street enclosure, complexity and connectivity of path network, building functions and attractions, complexity of space as variation, the elements above street level, buffer zone between pedestrian and vehicle, the presence of shade, transparency, physical conditions. In this study, only the physical parameters were evaluated by using one method to measure comfort level.

2. MATERIAL AND METHODOLOGY

2.1. Material

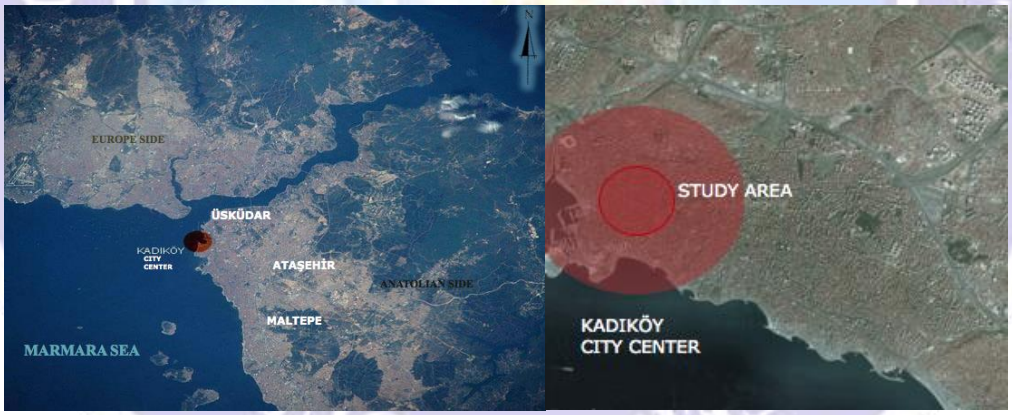


Figure 1 Study Area
Source: (This graphic is producted by using Google maps by authors)

Turkey's most populous city is İstanbul that is in the Marmara Region of Turkey. The city that connects Anatolia and Europe, the city along the Marmara shore and the Bosporus, has hosted many different civilizations in history. It is a metropolitan center which has many functions such as economy, tourism, industry, commerce, culture. On the other hand, Istanbul is a strategic location with links to highways, railways, airports and sea routes. This study was carried out in a district located in Kadıköy district center which is one of the most important metropolitan centers of Istanbul.

This area is mostly used by the pedestrians and the pedestrian density is high in Bahariye Street and Sakız Gülü Street. The pedestrian comfort level was measured in two phases over a street and connected another street in this selected region as material. Literature study on the selected region was conducted, data were collected from related institutions, data were collected on-site by field observations, submitted on 1/1000 scaled site plans.

Figure 2 Bahariye Street View[1],

Figure 3 Sakız Gülü Street[2]

2.2. Methodology

Primarily, a literature study was carried out on Kadıköy district and the subject. Solid-void, floor elevation, building quality, land use (ground floor and upper floors), sun-shading, transportation, green spaces, urban furniture and night lightning analysis and some measurements related to street texture and morphology were done to know more about the field and to have knowledge. Data is processed on 1/1000 scale sheet. An image map was also created by using observations note.

Two different comfort levels were analyzed for the two selected streets. In the pedestrian comfort analysis with pedestrian counts were used to calculate the level of service, and comfort level was calculated depending on physical conditions and the morphological structure. In the first phase of the comfort level analysis, pedestrian counts were collected in the most intensive 3 hours of the day (peak hours). Because of the vehicle traffic in the streets, the eastern and western sidewalks of the Bahariye Street and the south and north sidewalk of the Sakız Gülü Street have been measured and analyzed in both sides of the street. Various spatial analyzes have been carried out for analysis based on the physical structure. After the data was collected, measurement of pedestrian comfort levels was used which take part in Sarkar (2003) and Ocakçı (2010) publication. In these sources, they mentioned the levels of A, B, C, D, E were determined from the five-level table and how evaluated the comfort level.

3. RESULTS

When analysis results are evaluated, at the solid-void analysis, there is not a balanced occupancy rate because the density of the structure in the selected area is excessive. The density of the structure in the adjoining order does not allow the open space except outside the streets and the backyards of the buildings.

[1] Source: https://www.skyscrapercity.com/showthread.php?t=170012&page=10
[2] Source: http://mapio.net/pic/p-102632664/

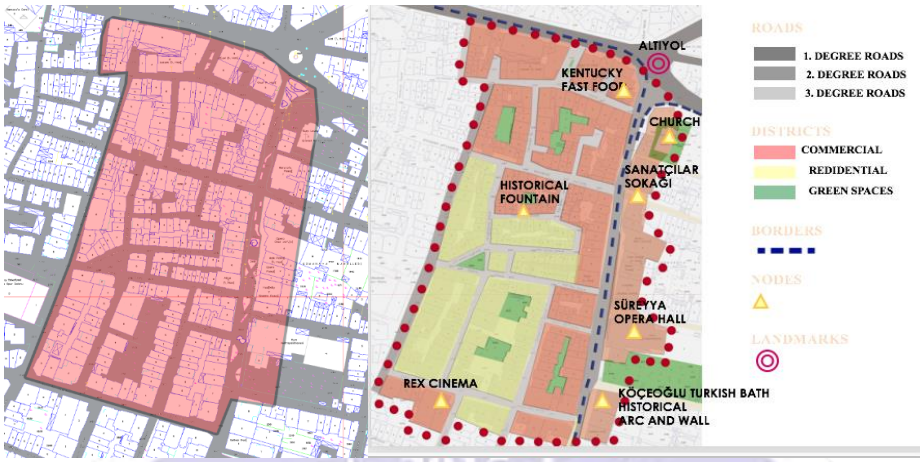


Figure 4 Study Area Site Plan

In the floor height analysis, it is seen that the structures surrounding the floor are at floor heights varying from 1 to 9 floors. The selected area has a maximum ratio of 2-5 floors. In the structural quality analysis classified as the ruins, poor, moderate, and good, the moderate level buildings are many, there are 3 buildings in ruins, and 5 renovated buildings with good reputations. There are wooden and concrete structures in the area. When analyzing land use, 29.8% are residential, 16.6% are office and retails, 16.6% are manufacturer services, 36.5% are personal services and 0.5% are social service areas. The commercial texture in the area is very diverse, and ground floor use has many different functions.

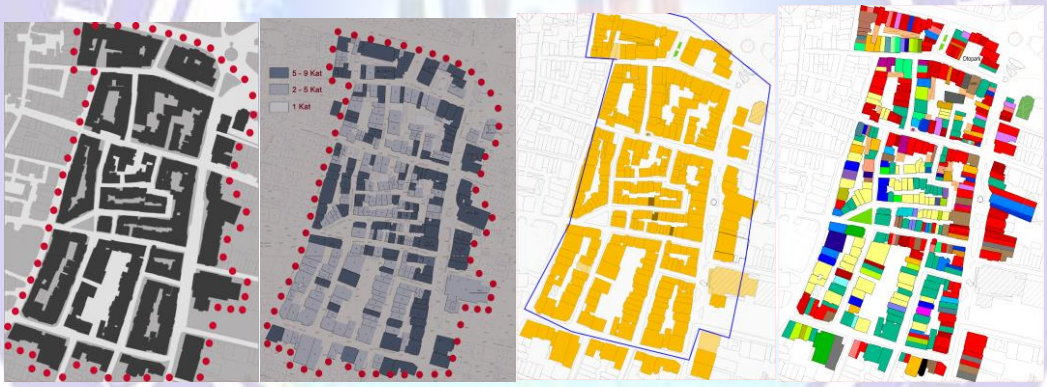
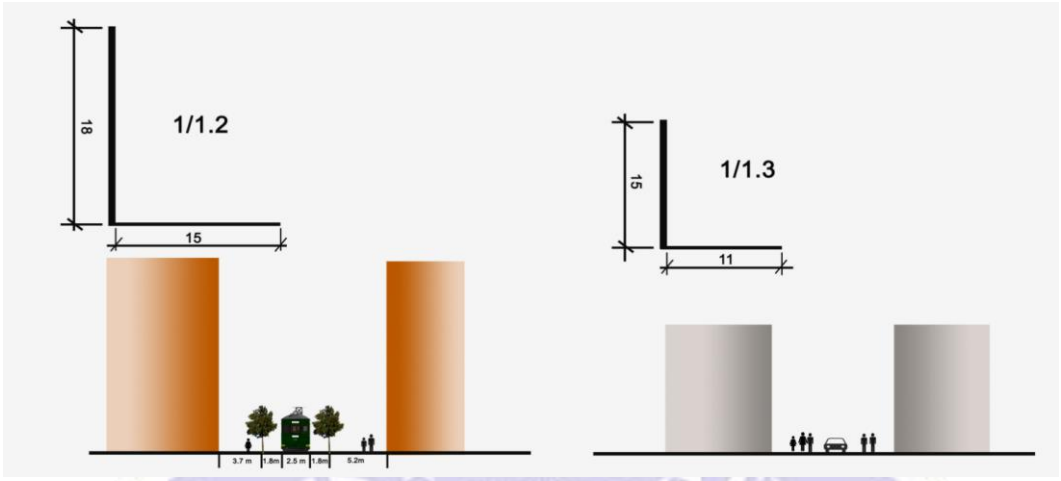


Figure 5 a.Solid-Void b.Floor Elevation c.Building Quality d. Land use analysis

The streets and streets have dimensions which form the street texture when typologically viewed in terms of height and width ratio. The continuity of the facade and the variety of functions in the use of space draw the user to this area. As identified in the transport analysis, the vehicle connections contribute positively to the area in terms of pedestrian connectivity, as well as pedestrian connections, as well as pedestrian crossings.

Figure 6 a.Sun-shade b.Transportation c.Green spaces d.Urban furniture analysis



BAHARİYE STREET	SAKIZ GÜLÜ STREET
The skydome effect +	The skydome effect +
Restrictive effect +	Restrictive effect +
Vertical surface Effect +	Vertical surface Effect -+

Figure 7 Street Section-Sense of Space

The study area was assessed by publications of Sarkar [12] and Ocakçı (2010), considering the usage levels at the peak hours in the weekday and weekend, and the service level depends on physical components in the pedestrian comfort level which has the five level.

Pedestrian counts were made during the weekdays and weekend peak hours at Bahariye Street and Sakız Gülü Street. On Bahariye Street weekday is mostly used in evening hours, and weekday noon is the busiest hour.

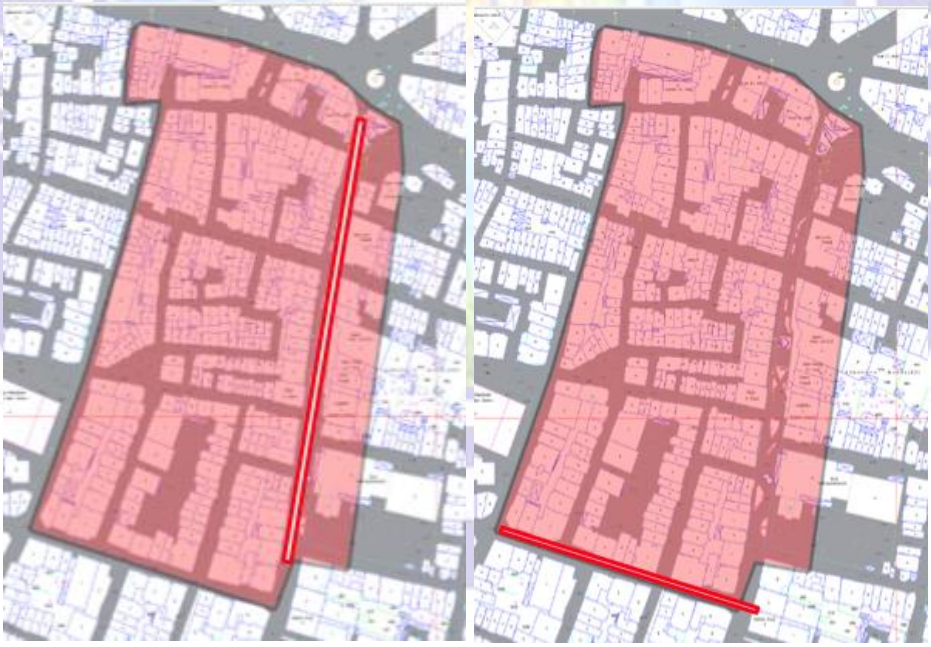


Figure 8 a.Bahariye Street Location b. Sakız Gülü Street Location

Table 1 Bahariye Street Weekday Pedestrian Count

Bahariye Street Weekday Pedesterian Count	Morning 8:00 – 9:00	Noon 12:00-13:00	Evening 17:00-18:00
Bahariye East Pavement	804	1200	3600
Bahariye West Pavement	1536	3816	9816

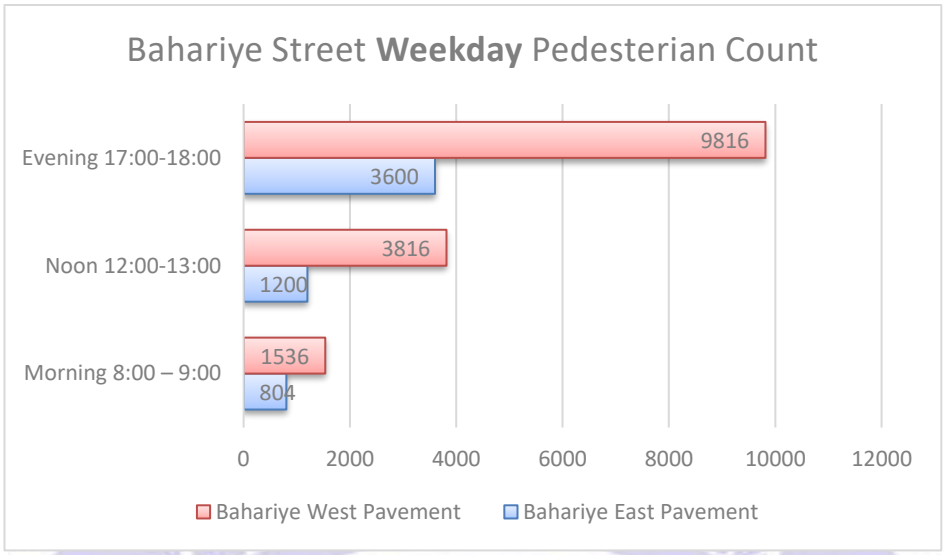


Figure 9 Bahariye Street Weekday Pedesterian Count Graph

Table 2 Bahariye Street Weekend Pedestrian Count

Bahariye Street Weekend Pedesterian Count	Morning 8:00 – 9:00	Noon 12:00-13:00	Evening 17:00-18:00
Bahariye East Pavement	480	1050	3126
Bahariye West Pavement	730	5118	1284

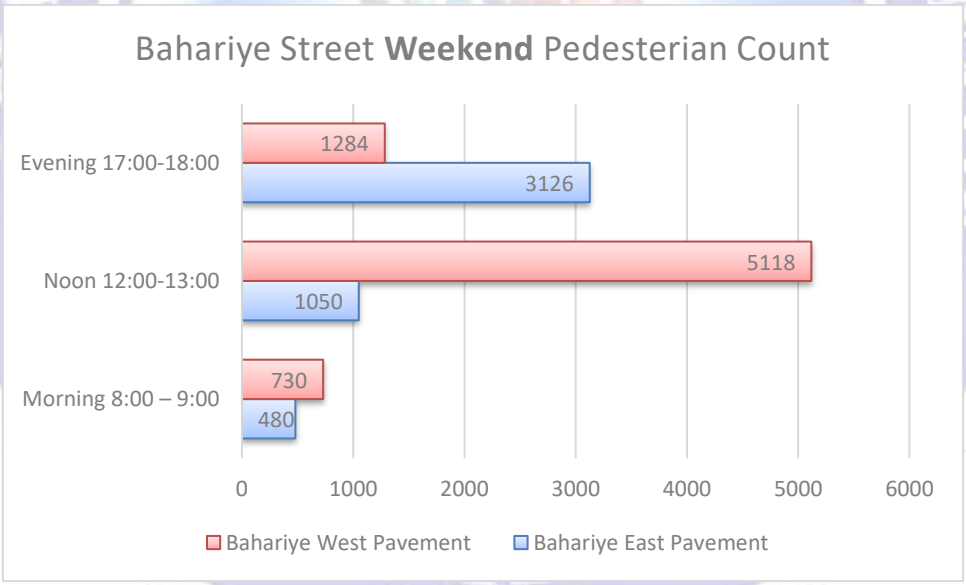


Figure 10 Bahariye Street Weekend Pedesterian Count Graph

At Sakız Gülü Street, the busiest pedestrian flow is observed at noon on weekdays, while weekends are the busiest hour in the evening in terms of pedestrian density.

Table 3 Sakız Gülü Weekday Pedestrian Count

Sakız Gülü Street Weekday Pedesterian Count	Morning 8:00 – 9:00	Noon 12:00-13:00	Evening 17:00-18:00
Sakız Gülü North Pavement	276	768	948
Sakız Gülü South Pavement	456	1164	708

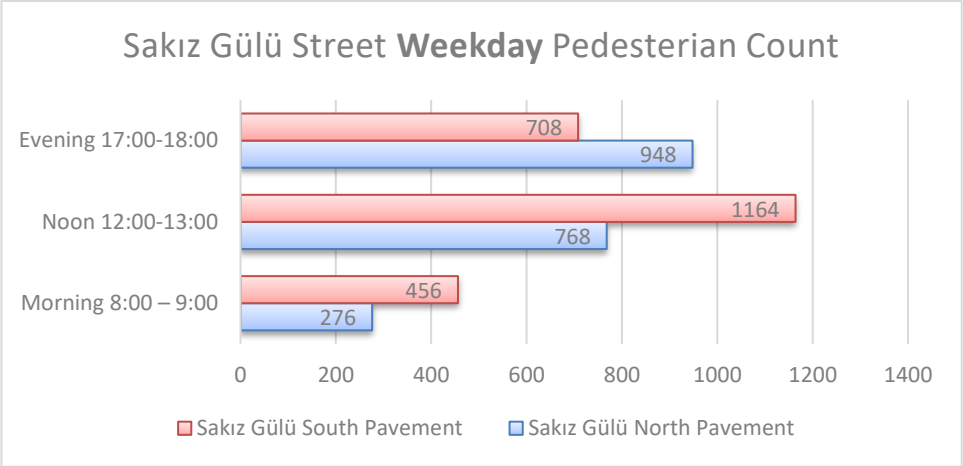
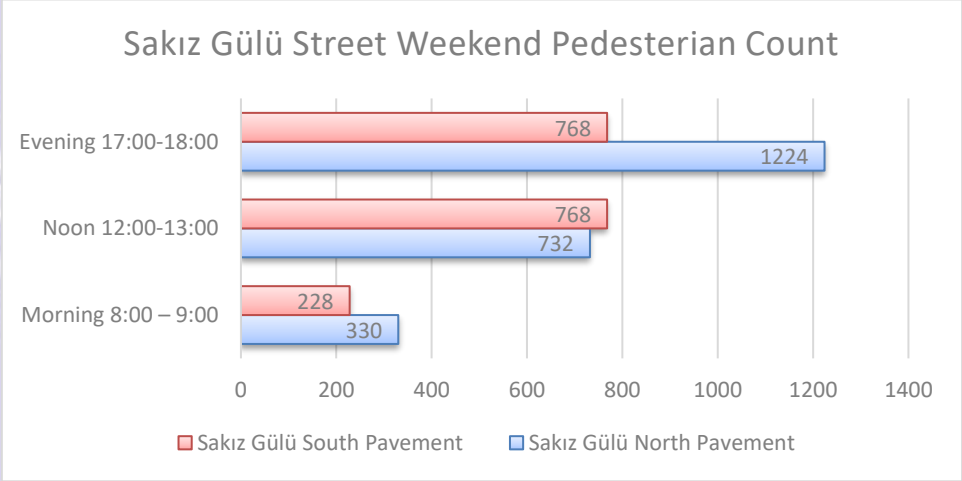


Table 4 Sakız Gülü Weekend Pedestrian Count

Sakız Gülü Street Weekend Pedesterian Count	Morning 8:00 – 9:00	Noon 12:00-13:00	Evening 17:00-18:00
Sakız Gülü North Pavement	330	732	1224
Sakız Gülü South Pavement	228	768	768



After the pedestrian counts have been made, the following table has been drawn up to find the level of service. Pedestrian flow rate was calculated by using pavement width, number of pedestrians and counting time, and the average speed of the pedestrian was calculated by the number of people per square meter. Based on these data, pedestrian service level was found for each census. During the daytime hours of the week, the east sidewalk of Bahariye Street is connected to the highest comfort level, while the weekday noon and evening hours are low level of comfort.

Table 5 Bahariye Street – Sakız Gülü Street Weekdays Morning Pedesterian Service Level

STREET NAME		PEAK HOURS	COUNT OF USER (person)	PAVEMENT WIDTH(m)	AVERAGE FLOW SPEED (1 HOUR)		AREA PER PERSON (m2 / person)	AVERAGE SPEED (m / min)	SERVICE LEVEL
					(person/minute)	(person/minute /meter)			
BAHARİYE STREET	EAST PAVEMENT	08:00-9:00	804	5,5	13,4	2,44	2,6	75	B
	WEST PAVEMENT	08:00-9:00	1536	6,9	25,6	3,72	1,71	70	C
SAKIZ GÜLÜ STREET	NORTH PAVEMENT	08:00-9:00	276	3	4,6	1,54	2,09	72	C
	SOUTH PAVEMENT	08:00-9:00	456	5	7,6	1,52	2,11	72	C

Table 6 Bahariye Street-Sakız Gülü Street Weekday Noon Pedestrian Service Level

STREET NAME		PEAK HOURS	COUNT OF USER (person)	PAVEMENT WIDTH(m)	AVERAGE FLOW SPEED (1 HOUR)		AREA PER PERSON (m2 / person)	AVERAGE SPEED (m / min)	SERVICE LEVEL
					(person/minute)	(person/minute /meter)			
BAHARİYE STREET	EAST PAVEMENT	12:00-13:00	1200	5,5	20	3,64	1,74	70	C
	WEST PAVEMENT	12:00-13:00	3816	6,9	63,6	9,22	0,69	63	E
SAKIZ GÜLÜ STREET	NORTH PAVEMENT	12:00-13:00	768	3	12,8	4,26	0,75	63	E
	SOUTH PAVEMENT	12:00-13:00	1164	5	19,4	3,88	0,83	64	E

Table 7 Bahariye Street-Sakız Gülü Street Weekday Evening Pedestrian Service Level

STREET NAME		PEAK HOURS	COUNT OF USER (person)	PAVEMENT WIDTH(m)	AVERAGE FLOW SPEED (1 HOUR)		AREA PER PERSON (m2 / person)	AVERAGE SPEED (m / min)	SERVICE LEVEL
					(person/minute)	(person/minute /meter)			
BAHARİYE CADDESİ	DOĞU KALDIRIMI	17:00-18:00	3600	5,5	60	10,91	0,59	62	E
	BATI KALDIRIMI	17:00-18:00	9816	6,9	163,6	23,72	0,26	56	E
SAKIZ GÜLÜ SOKAK	KUZEY KALDIRIMI	17:00-18:00	948	3	15,8	5,27	0,61	62	E
	GÜNEY KALDIRIMI	17:00-18:00	708	5	11,8	2,36	1,36	66	D

While Sakiz Gülü Street has high service level during daytime during weekdays, it is seen that there is a decrease in comfort level with increasing density towards evening hours.

Table 8 Bahariye Street – Sakız Gülü Street Weekend Morning Pedesterian Service Level

STREET NAME		PEAK HOURS	COUNT OF USER (person)	PAVEMENT WIDTH(m)	AVERAGE FLOW SPEED (1 HOUR)		AREA PER PERSON (m2 / person)	AVERAGE SPEED (m / min)	SERVICE LEVEL
					(person/minute)	(person/minute /meter)			
BAHARİYE STREET	EAST PAVEMENT	08:00-9:00	480	5,5	8	1,45	4,35	83	A
	WEST PAVEMENT	08:00-9:00	730	6,9	12,16	1,76	3,59	80	A
SAKIZ GÜLÜ STREET	NORTH PAVEMENT	08:00-9:00	330	3	5,5	1,83	1,74	70	C
	SOUTH PAVEMENT	08:00-9:00	228	5	3,8	0,76	4,21	82	A

Table 9 Bahariye Street – Sakız Gülü Street Weekend Noon Pedesterian Service Level

STREET NAME		PEAK HOURS	COUNT OF USER (person)	PAVEMENT WIDTH(m)	AVERAGE FLOW SPEED (1 HOUR)		AREA PER PERSON (m2 / person)	AVERAGE SPEED (m / min)	SERVICE LEVEL
					(person/minute)	(person/minute /meter)			
BAHARİYE STREET	EAST PAVEMENT	12:00-13:00	1050	5,5	17,5	3,18	1,99	71	C
	WEST PAVEMENT	12:00-13:00	5118	6,9	85,3	12,36	0,51	61	E
SAKIZ GÜLÜ STREET	NORTH PAVEMENT	12:00-13:00	732	3	12,2	4,06	0,78	63	D
	SOUTH PAVEMENT	12:00-13:00	768	5	12,8	2,56	1,25	65	D

Table 10 Bahariye Street – Sakız Gülü Street Weekend Evening Pedesterian Service Level

STREET NAME		PEAK HOURS	COUNT OF USER (person)	PAVEMENT WIDTH(m)	AVERAGE FLOW SPEED (1 HOUR)		AREA PER PERSON (m2 / person)	AVERAGE SPEED (m / min)	SERVICE LEVEL
					(person/minute)	(person/minute /meter)			
BAHARİYE STREET	EAST PAVEMENT	17:00-18:00	3126	5,5	52,1	9,47	0,66	62	E
	WEST PAVEMENT	17:00-18:00	1284	6,9	21,4	3,1	2,04	71	C
SAKIZ GÜLÜ STREET	NORTH PAVEMENT	17:00-18:00	1224	3	20,4	6,8	0,47	60	E
	SOUTH PAVEMENT	17:00-18:00	768	5	12,8	2,56	1,25	65	D

According to the weekly pedestrian intensity analysis, the pedestrian was mostly used this area in the evening hours and at the weekend in the most noon and evening hours. Service levels at levels A and E were found for both streets. Bahariye Street and Sakız Gülü Street have reached the highest level of service (A) during the weekdays during the daytime hours. When determining this level, the time, m2 per person, pedestrian flow speed in the area has been calculated.

Table 11 Bahariye Street Pedestrian Service Level

PEDESTERIAN COMFORT LEVEL – BAHARİYE STREET-(Physical Conditions)	**A LEVEL**	**B LEVEL**	**C LEVEL**	**D LEVEL**	**E LEVEL**
10-12 buildings within 100 m distance		♦			
Functional differentiation and land use at a certain level		♦			
An average of 15 doors and windows in every 100 m		♦			
No deaf front facing the street	♦				
No passive façade on the ground floor	♦				
Level of variability, depth and height on building facades			♦		
Use of standard quality materials on building facades			♦		
RESULTS	2	3	2	0	0
		B LEVEL			

Table 12 Sakız Gülü Street Pedestrian Service Level

PEDESTERIAN COMFORT LEVEL –SAKIZ AGACI STREET- (Physical Conditions)	A LEVEL	B LEVEL	C LEVEL	D LEVEL	E LEVEL
3-5 buildings within 100 m distance				♦	
Functional differentiation and land use at a medium level			♦		
No deaf front facing the street	♦				
No passive façade on the ground floor	♦				
Level of variability, depth and height on building facades			♦		
Use of standard quality materials on building facades			♦		
TOTAL VALUES	2	0	3	1	0
COMFORT LEVEL			**C LEVEL**		

4. CONCLUSION and RECOMMENDATIONS

The center of Kadikoy is an important part of the city in terms of street texture and the functions it hosts. The research area is Bahariye Street which is one of the most important points of the Kadıköy Center and Sakız Gülü Street which is connected to it is one of the areas heavily used by pedestrians. As a result of the analysis made, Bahariye Street has reached total comfort level E, Sakiz Gülü Street is D level. These levels are poor quality for pedestrian walking comfort level. Acceptance of these levels causes the speed to drop with the increase of the number of pedestrians, which causes the area per person to decrease and the movement of pedestrians to slow down.

Table 13 Bahariye Street – Sakız Gülü Street Pedesterian Comfort Level

PEDESTERIAN COMFORT LEVELS Result Table		**A**	**B**	**C**	**D**	**E**
Bahariye Street(East/West Pavement)	Weekday Morning		X	X		
	Weekday Noon			X		X
	Weekday Evening					2X
	Weekend Morning	2X				
	Weekend Noon			X		X
	Weekend Evening			X		X
	Service Level on Physical Conditions		X			
TOTAL VALUES		2	1	4	-	5
TOTAL PEDESTERIAN COMFORT LEVEL		**E level**				
Sakız Gülü Street (South/North Pavement)	Weekday Morning			X	X	
	Weekday Noon					2X
	Weekday Evening				X	X
	Weekend Morning	X		X		
	Weekend Noon				2X	
	Weekend Evening				X	X
	Service Level on Physical Conditions			X		
TOTAL VALUES		1	-	3	5	4
TOTAL PEDESTERIAN COMFORT LEVEL		**D level**				

Qualities required for high levels of pedestrian comfort in areas with strong dynamics in terms of walkability; safety, security, convenience and comfort, continuity, system coherence, attractiveness

and physiological parameters as climate, noise (Sarkar, 1993). Ensuring optimum conditions in these parameters can be achieved by accurate design and application phases in pedestrian roads. Traffic flow, safety, pedestrian movement, street connectivity, choosing right material is the main parameters for comfort. It is recommended that the measurement of comfort level must be measured periodically for control the parameters and to interfere with negative parameters on time.

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