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RESEARCH ARTICLE

EXAMINING THE ACCESSIBILITY OF SIDEWALKS FOR WHEELCHAIR USERS: THE CASE OF EFELER CITY (AYDIN/TURKIYE)

Barış Kara[1], Ozlem Kazmacı[2], Buse Ar[2], Cansu Aykan[2], Ayşenur Bayram[2], Sezen Ozçetin[2], Ozgur Ozsoy[2] and Melike Yaman[2]

1. Professor Doctor, Department of Landscape Architecture, Aydın Adnan Menderes University, Aydın, Türkiye.
2. Student, Department of Landscape Architecture, Graduate School of Natural and Applied Sciences, Aydın Adnan Menderes University, Aydın, Türkiye.

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Abstract

This study examined the accessibility of the sidewalks of the boulevards in the city center of the Efeler district of Aydın Province (Türkiye) for wheelchair users. The variables defining the comfort and safety aspects of the sidewalks for wheelchair users were weighted and addressed. This study is important because it contributes to the participation of wheelchair users in public life.The "unevenness of over 10 cm in height, with or without concordance (steps)/V_1" on Atatürk, Doğu Gazi, and İstasyon Boulevards should be reduced. Sidewalks on Atatürk Boulevard, Batı Gazi Boulevard, Doğu Gazi Boulevard, İstasyon Boulevard, and Vali Konağı Boulevard should be repaired since they are "Full of holes and loose stones, etc. (impracticable for use)/V_2." Continuity in the sidewalks should be ensured by eliminating the interruptions in the segments as "No pavement or vegetal covering (grass)/V_3" on Atatürk, Doğu Gazi, and İstasyon Boulevards. The obstacles, such as "Sidewalk totally obstructed/ no sidewalk. Impossible wheelchair movement/V_4" should be removed on Atatürk, Doğu Gazi, and İstasyon Boulevards, and passageways for wheelchair users on the sidewalks should be provided. Six boulevards (Atatürk Boulevard, Batı Gazi Boulevard, Doğu Gazi Boulevard, Hükümet Boulevard, İstasyon Boulevard, and Vali Konağı Boulevard) should be improved in terms of "Inadequate intersections, without ramps, without zebra crossings, and without traffic lights/V_5." Pedestrian crossings should be made striped, and traffic signals should be timed.The boulevards with the highest mean score for variable 1 (V_1) (5.00/Excellent) are Adnan Menderes Boulevard and Hükümet Boulevard; the boulevard with the highest mean scores for V_2 and V_3 (4.50 and 4.91, respectively/Very good) is Batı Gazi Boulevard; the boulevard with the highest mean scores for V_4 and V_5 (4.93/Very good and 2.68/Fair, respectively) is Adnan Menderes Boulevard; the boulevard with the highest Sidewalk Accessibility Index (SAI) score (4.05/Very good) is Batı Gazi Boulevard. The Level of Service (LS) of Batı Gazi Boulevard's sidewalks is "B." "The wheelchair user can move around without obstacles" on Batı Gazi Boulevard's sidewalks.

Corresponding Author:-Barış Kara
Address:-Professor Doctor, Department of Landscape Architecture, Aydin Adnan Menderes University, Aydin, Turkiye.

Introduction:-

Mobility, which is defined as the ability to walk safely and independently, represents a critical requirement for carrying out activities of daily living.[1] As shown by,[2]a mobility impairment in walking is related to difficulty walking. A mobility impairment can be congenital or acquired,[3]and the nature of the built environment is critical for individuals with such disabilities. The quality of life decreases in individuals who experience restrictions in independence.[4,5]

A sidewalk is defined as a section of a highway, road, or street that is designated for pedestrians. Pedestrians are individuals who travel on foot or use assistive devices, such as wheelchairs,for mobility.[6]Sidewalks enable pedestrians to move around the city, which positively affects people's quality of life and urban mobility.[7-9]Existing sidewalks not only provide individuals with disabilities with a privileged right of way around the world, but also protect pedestrians from road accidents and offer the opportunity to enjoy the environment's aesthetics.[10,11]Sidewalks are the structuring element of pedestrian transportation in the urban environment. Hence, sidewalks should provide movement conditions for all pedestrians.[12]

Individuals without limited physical mobility may not notice some physical properties of sidewalks,or can overcome them. However, these properties often create real barriers that lead to discrimination for individuals with physical disabilities and prevent them from using public spaces.[13]Sidewalk features, such as irregularities in grade, protruding objects, clear widths, and pedestrian crossings, determine sidewalks' accessibility for individuals with disabilities.[14]Such sidewalks are not suitable for walking because of the inappropriate materials used in their construction, the presence of obstacles, or they aredangerous.

Accessibility features directly impact a sidewalk's usability.[6]Many sidewalks are not wheelchair-friendly. Changes in the grade on a sidewalk can make traveling on the sidewalk impossible for wheelchair users.[15]Changes in grade can cause a manual wheelchair's wheels to catch on the sidewalk, causing the wheelchair to stop.[6]Uneven sidewalks can considerably impede wheelchair users' mobility because of surface roughness.[15]A surface refers to the material on which an individual walks or uses a wheelchair in a pedestrian environment. The surface type determines how complex an area is to traverse.[6]A solid and stable surface, such as concrete, reduces the rolling resistance experienced by a wheelchair.[16]The surface texture of sidewalk ramps should be rough enough to ensure skid resistance when wet.[6]

The sidewalk's effective width, not the design width, determines the sidewalk area required to meet the expected pedestrian traffic levels. Obstacles reducing the minimum clearance width, such as trash cans, utility poles,[17]and decorative flower pots on a narrow sidewalk,can create considerable barriers for walker or wheelchair users[6]and impede passage.[17]Wider sidewalks allow for more pedestrian traffic and increase accessibility for strollers and wheelchairs.[17]

Street crossings can be uncontrolled (with no traffic signal) or controlled (with a traffic signal),[18]and pedestrian crossings can be marked or unmarked.[19]Electronically activated pedestrian crossings use alternative applications, such as raised pedestrian crossings, pedestrian-operated traffic controls, flashing traffic signals, and illuminated pedestrian crossing warning lights.[6]Pedestrian countdown signals are becoming popular since they allow pedestrians to determine whether they have enough time to cross the road according to their individual walking speed, rather than a predetermined crossing time based on an average walking speed.[17]

Numerous studies have been conducted in the literature on the factors and obstacles that impact the accessibility of wheelchair users in urban spaces.There are few studies on the lack of sidewalks, their quality levels, and accessibility.Kockelman et al.[20] defined the following factors impacting the perception of comfort while traveling on sidewalks (for individuals withdisabilities): the length of the sidewalk's continuous section exceeding 2% of the cross slope; the ratio of the sidewalk's total length exceeding 2% of the cross slope; the volume of the automobile traffic on the adjacent roadand the separation distance from this traffic; the condition of the sidewalk pavement (type, texture, state of repair); longitudinal downgrade slope of the sidewalk; climate; sidewalk width; accessibility of the entire route (including curb cuts, street crossings, etc.).

Oeda and Sumi[21]suggested a method for evaluating sidewalk roughness from the wheelchair users' perspective. The perceived level of discomfort was recorded on a scale from 1 to 5 (discomfort increases with an increase in the value). This study defined a function associating the level of vibration with the level of discomfort.

Evans-Cowley[22]showed the lack of sidewalk maintenance as an essential factor in the pedestrian environment's poor quality.

Ishida et al.[15]analyzed sidewalks' longitudinal profiles to suggest a method to evaluate sidewalk surface roughness based on the travel resistance imposed on wheelchairs.The study revealed a strong correlation between the surface roughness values calculated using the suggested method and the discomfort reported by panel members.Sousa et al.[9]conducted a field study comprising 23 sidewalks from diverse locations in Coimbra City, Portugal.According to the results, a significant part of the sidewalks was in mediocre condition.da Rocha et al[12]performed a technical evaluation of sidewalks based on the maintenance, effective width, and accessibility quality indicators.

The Nitsch Engineering Stantec Pedestrian Accessibility Study[23]examined sidewalk material type, sidewalk visual rating (a general condition), sidewalk width, sidewalk slope, crosswalk presence, and Accessible Pedestrian Signal (APS) presence. At the stage of field data collection, various trip hazards and pinch points (points where the sidewalk width is less than 90 cm because of obstacles such as trees, telephone poles, etc.) were identified.

In most cities in Türkiye, sidewalks mean discomfort and a lack of safety for pedestrians, particularly individuals with disabilities, and sometimes pose a danger. Sidewalks often contain obstacles that make proper circulation challenging and are made of inappropriate materials. Unfortunately, many sidewalks do not meet the needs of individuals with disabilities, constituting 6.9% of the Turkish population according to official numbers[24]and 13% according to unofficial numbers.[25]

The current research presents a method for assessing sidewalks and street crossings, aiming to identify accessible routes in cities based on the expectations and needs of wheelchair users. The method in question assigns weights to variables that define comfort and safety aspects for wheelchair users. This article aims to assess the sidewalk quality level and accessibility of the city of Efeler (Aydın/Türkiye).

Materials and Methods:-

The method and parameters employed in this study were developed from techniques used in previous studies.[12,13]Kockelman et al.[20]identified the variables within this method that influence the comfort perception of individuals with disabilities when navigating sidewalks. The use of the Sidewalk Accessibility Index (SAI) and service-level categorization offers a systematic assessment approach, which is a strength of the study. The study is important because it is the first to use the Sidewalk Accessibility Index (SAI) and Level of Service categorization in conjunction. The present study examined seven boulevards with different directions in the Efeler district center of Aydın Province. The boulevards were divided into two groups (vertical and horizontal) according to their directions; the sidewalks of vertical boulevards were grouped as east-west, while the sidewalks of horizontal boulevards were grouped as north-south (Figure 1).Variables related to sidewalks' and street crossings' characteristics (Table 1) and possible descriptive qualities depending on the change in each variable (Table 2) were created. The most important descriptive qualities of the variables characterizing the comfort and safety aspects of sidewalks and street crossings were classified according to their order of importance. The classification was scored from 0 to 5; 0 points refer to the least importance, while 5 points refer to the highest importance (Table 2).

The average scores of the sidewalks' and street crossings' variables were found by taking the average of the scores of the variables' descriptive qualities. The average scores of the boulevards' variables were determined by averaging the variables' scores of east-west or north-south sidewalks. The boulevards'Sidewalk Accessibility Index (SAI) score was found by averaging the scores of the boulevards' variables (Equation 1).According to the SAI score, the sidewalks' condition, Level of Service (LS), and the level of usability by wheelchair users were determined (Table 3). The sidewalk assessment form used at the stage of the field study was created. Field assessments were performed, and the findings were recorded in tables designed. All variables were assessed in the sidewalk segment, where any of the variables changed. The analysis was conducted for each segment along the entire sidewalk, and the average of the assessed segments was taken. The assessments were performed on 495 segments on the sidewalks and 196 street crossings. ANOVA analysis in SPSS software tested whether there was a significant difference between the variables' averages.

The method above can be implemented by municipal decision-makers, regardless of city location and size. Simplicity and ease of data collection are significant features that can ensure the broad applicability of the current method. Using the scientific multi-criteria method fills a gap in the literature, as previous approaches to the subject have employed simpler models. The method's output is straightforward, making it easier for decision-makers to gain an overview of the sidewalk network and assess opportunities for improvement.

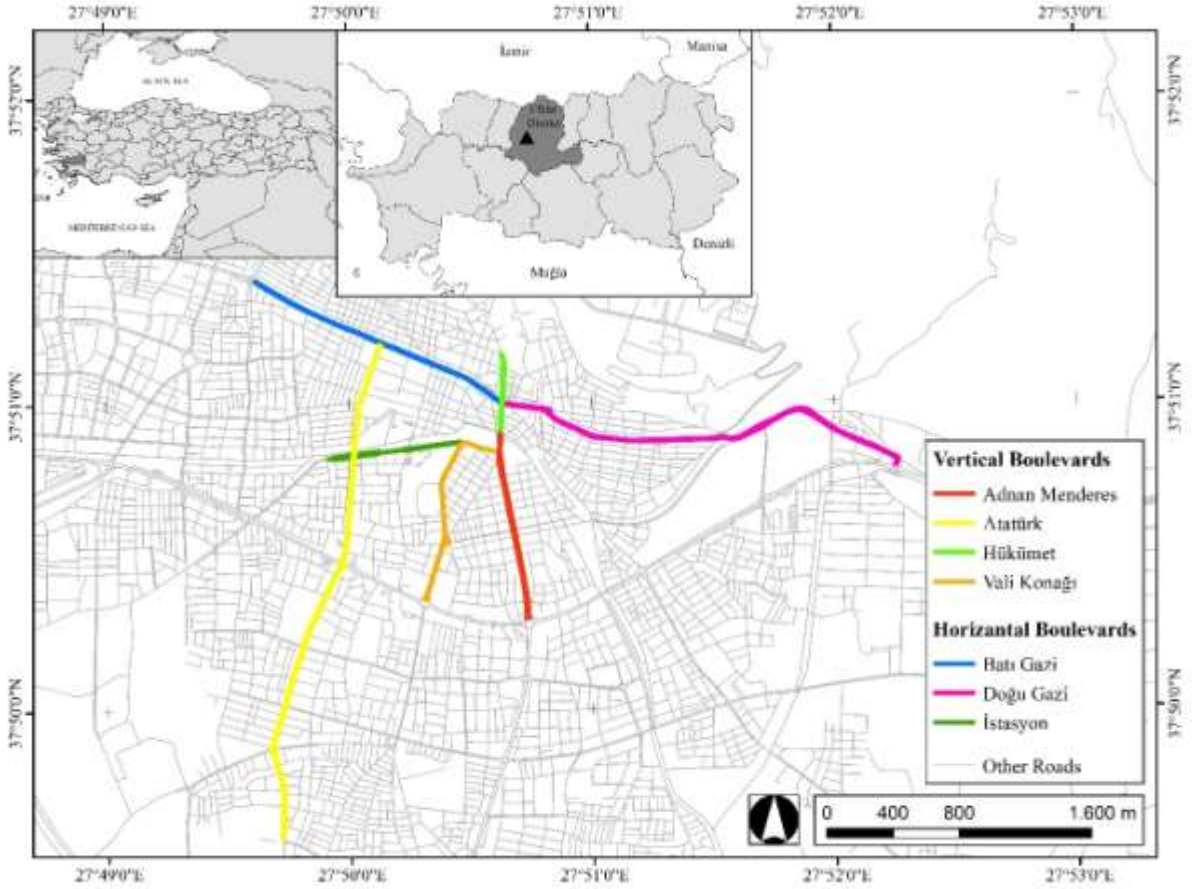


Figure 1. Location of the study area

Table 1. Variables that determine the physical infrastructure of sidewalks[13]

Variables		Representation
1	Longitudinal profile (leveling of the grade)	Change in the sidewalk profile along the block.
2	Surface of the sidewalk pavement	Condition of the sidewalk surface in terms of maintenance quality.
3	Material used on the sidewalk surface	Suitability of the material types used in sidewalk construction.
4	Effective width of the sidewalk	Free width is available to circulate sidewalk users.
5	Intersection of urban streets	Suitability of street intersections in terms of equipment, signs, and facilities.

Table 2. Descriptions and scores related to the assessment variables of sidewalks[13]

	Variables				
	1	2	3	4	5
	Longitudinal Profile of the Sidewalk Surface (Change of grade level)	Surface of the Sidewalk Pavement	Materials Used in the Sidewalk Pavement	Effective Width of the Sidewalk (Free Area for Movement)	Intersections of Urban Streets–Suitableness of Street Crossings (Safe Crossing)
Point	Description of the Quality				
5	No unevenness (regular)	Excellent conditions, well-maintained	Regular, firm, antiskid, and antivibration material (high-strength paving)	Free of obstacles. Free area width larger than 2.0 m	Good intersections with ramps, zebra crossings, and traffic lights with exclusive pedestrian time
4	Unevenness of up to 0.5 cm	Good conditions (cracks and other problems are repaired)	Rough material (hydraulic tiles, interlocked blocks, flattened concrete)	Free of obstacles. Free width larger than 1.5 m. No street vendors or for other irregular uses	Good intersections with ramps, zebra crossings, and traffic lights without exclusive time for pedestrians
3	Unevenness between 0.5 and 1.5 cm, on a 1:2 ramp	Regular conditions (small cracks and worn paving material)	Slippery material (smooth ceramic tiles)	Free width larger than 1.5 m at some points. Permits continued movement of wheelchairs.	Intersections with ramps, with zebra crossings, and without traffic lights
2	Unevenness between 1.5 and 5.0 cm in height, with or without concordance (steps)	Precarious conditions (some holes or irregularities with shallow depths)	Paving stones, rustic natural stones, and Portuguese mosaic stones	Free width area larger than 1.5 m at some points. Requires maneuvers in wheelchair movements.	Intersections with ramps, no zebra crossing, no traffic lights, right and left vehicle turns
1	Unevenness between 5.0 and 10.0 cm in height, with or without concordance (steps)	Poor conditions (irregularities and deformations caused by tree roots)	Flat segmented concrete slabs (separated by grass or other material	Free area width around 0.80 m. Obstructions impair wheelchairs' movement	Intersections with no ramps, with zebra crossings, and with traffic lights without pedestrian-exclusive time
0	Unevenness of over 10 cm in height, with or without concordance (steps)	Full of holes and loose stones, etc. (impracticable for use)	No pavement or vegetal covering (grass)	Sidewalk totally obstructed/no sidewalk. Impossible wheelchair movement	Inadequate intersections without ramps, without zebra crossings, and without traffic lights

The Sidewalk Accessibility Index (SAI) is calculated through equation (1).

$$SAI = [V_1(Avg.) + V_2(Avg.) + V_3(Avg.) + V_4(Avg.) + V_5(Avg.)]/5 \quad \text{(Equation 1)}$$

Table 3. The Sidewalk Accessibility Index (SAI) and Level of Service (LS)values are used in evaluating sidewalks[12,13]

SAI	LS	Condition	Description
= 5.0	A	Excellent	The wheelchair user can move around without obstacles.
4.0 ≤ SAI< 5.0	B	Very good	The wheelchair user can move around without obstacles.
3.0 ≤ SAI< 4.0	C	Good	The wheelchair user can move around with some difficulty.
2.0 ≤ SAI < 3.0	D	Fair	The wheelchair user needs assistance to move around.
1.0 ≤ SAI < 2.0	E	Poor	The wheelchair user depends on assistance and has to maneuver to move around.
SAI < 1.0	F	Terrible	It is impossible for the wheelchair user to move around.
SAI: Sidewalk Accessibility Index; LS: Level of Service			

Table 4 has the number of segments, the number of pedestrian crossings, and the lengths of the two opposite sidewalks on the boulevard. Atatürk Boulevard, one of the vertical boulevards, is the longest boulevard in the study, with a length of 3127.40meters, and there are 24 segments and 14 pedestrian crossings on the east sidewalk and 29 segments and 12 pedestrian crossings on the west sidewalk. Hükümet Boulevard (470.80 m), the shortest, displays a more balanced distribution with similar numbers of segments (east: 16, west: 17) and pedestrian crossings (east: 7, west: 4) between the east and west sidewalks.Despite the high number of segments on both sidewalks (east: 51, west: 54), Adnan Menderes Bolevardhas a lower number of pedestrian crossings (east: 14, west: 8). There is an asymmetry on İstasyon Boulevard; while there are 54 segments and 20 crossings on the south sidewalk, there are only 33 segments and 5 crossings on the north sidewalk (Table 4).

Table 4. Analysis of sidewalk distribution on the examined boulevards based on direction, segment count, street crossings, and total length

Boulevards	Direction	Sidewalk	Segment (n)	Street Crossings (n)	Length (m)
Adnan Menderes	Vertical	East	51	14	1162.45
		West	54	8	
Atatürk	Vertical	East	24	14	3127.40
		West	29	12	
Batı Gazi	Horizontal	North	23	15	1677.40
		South	40	15	
Doğu Gazi	Horizontal	North	55	28	2613.70
		South	41	29	
Hükümet	Vertical	East	16	7	470.80
		West	17	4	
İstasyon	Horizontal	North	33	5	834.30
		South	54	20	
Vali Konağı	Vertical	East	45	17	1230.30
		West	13	8	

Results:-

Figure 2 displays the distribution of SAI values of the sidewalks on the studied boulevards by segments. Comparing the accessibility levels of sidewalks on boulevards according to their directions also gives important data. A high SAI value shows better accessibility. Both the east and west sidewalks on Adnan Menderes Boulevard have relatively high SAI values. The distribution is narrow,which shows consistent accessibility. The SAI values on Atatürk Boulevard show a wider distribution: lower on the west sidewalk, whereas the east sidewalk has a similar distribution. This boulevard should be improved in terms of accessibility.

Both sidewalks on Hükümet Boulevard have high accessibility values, and the accessibility is consistent.Whereas the east sidewalk on Vali Konağı Boulevard offers high accessibility, accessibility on the west sidewalk is lower, and the distribution is wider. This suggests that the west sidewalk has inconsistent accessibility standards.Both the north and south sidewalks of Batı Gazi Boulevard have high SAI values.It boasts a highly successful profile regarding accessibility due to its narrow distribution. Both the north and south sidewalks on Doğu Gazi Boulevard have variable accessibility. Low extreme values show that significant accessibility problems may occur on these sidewalks.The SAI values on İstasyon Boulevard are at the“Good”level (~3.5), the distribution is broad, and there are a few extreme values. This boulevard has“Good”accessibility but is open to improvement in some areas.

ANOVA did not show a significant difference between the sidewalk directions for SAI ($p>0.05$). However, one direction has considerably lower accessibility than the other on some boulevards (e.g., Vali Konağı, Atatürk).There is a significant difference between the boulevards concerning SAI values ($p<0.05$).Whereas Adnan Menderes, Hükümet, and Batı Gazi Boulevards have the highest averages, Atatürk, Doğu Gazi, and İstasyon Boulevards display the lowest values (Figure 2).

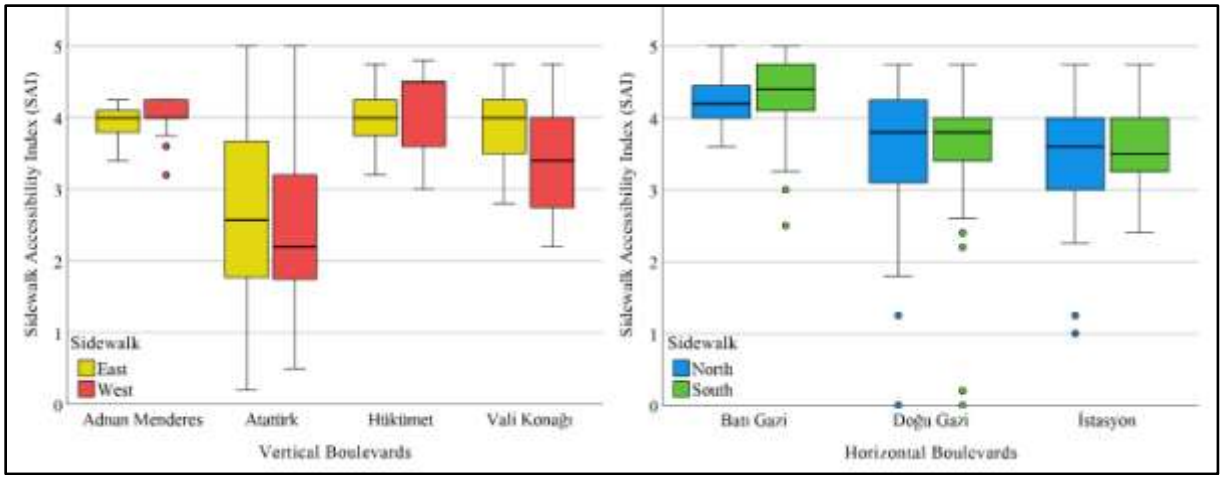


Figure 2. Boxplot diagrams of the Sidewalk Accessibility Index (SAI) by segments of Aydın boulevards ($F_{Boulevards}$=31.394, p=0.000; $F_{Sidewalk}$=1.085, p=0.355)

Table 5 lists the average values of the variables (V_1–V_5) calculated according to the boulevards' sidewalk directions (east, west, north, and south) and the Sidewalk Accessibility Index (SAI) value created based on these values. As seen in the table, the accessibility levels of the sidewalks in various directions of different boulevards differ. The SAI value of the boulevards' sidewalks in both directions is above 3.00 and is in the "Good" category. However, the SAI values of Atatürk Boulevard's sidewalks in both directions and the north sidewalk of İstasyon Boulevard are below these values and are in the "Fair" category. Only the SAI values of Batı Gazi Boulevard's sidewalks in both directions are above 4.00 and are in the "Very good" category.

One of the highest accessibility levels was detected at 4.09, especially on the south sidewalk of Batı Gazi Boulevard. Significant imbalances in the variables on the sidewalks draw attention. While V_1 (longitudinal profile of the sidewalk surface (change of grade level)) takes high values, V_5 (intersections of urban streets–suitability of street crossings (safe crossing)) has low values on some boulevards, reducing the overall SAI scores. For instance, whereas V_1 and V_3 are pretty high on the south sidewalk of İstasyon Boulevard, V_5 is very low, and this decrease pulled the SAI value down to 3.37.Very low V_5 values on Atatürk Boulevard's sidewalks in both directions are also remarkable. There are differences in terms of accessibility between the sidewalk directions of the boulevards in the table, which reveal areas that should be improved in terms of urban planning.

Table 5.The average scores and SAI scores of the sidewalk variables are categorized by direction

Boulevards	Sidewalk	V_1(Avg.)	V_2(Avg.)	V_3(Avg.)	V_4(Avg.)	V_5(Avg.)	SAI
Adnan Menderes	East	5.00	3.22	3.00	5.00	2.36	3.71
	West	5.00	3.33	3.07	4.85	3.00	3.85
Atatürk	East	3.08	2.42	3.96	1.75	0.86	2.41
	West	2.76	1.93	4.24	1.79	0.83	2.31
Batı Gazi	North	4.78	4.52	5.00	3.96	1.80	4.01
	South	4.65	4.48	4.83	4.15	2.33	4.09
Doğu Gazi	North	4.58	3.22	4.20	2.87	1.61	3.30
	South	4.39	3.17	4.27	3.27	1.48	3.32
Hükümet	East	5.00	3.38	4.75	3.69	1.86	3.73
	West	5.00	3.71	4.76	3.47	2.50	3.89
İstasyon	North	4.97	3.30	3.67	2.03	0.80	2.95
	South	4.57	3.19	4.20	3.17	1.70	3.37
Vali Konağı	East	4.71	3.91	4.87	2.67	2.06	3.64

	West	3.77	3.23	4.69	2.69	2.13	3.30
Terrible: <1.00; Poor: 1.00≤x<2.00; Fair: 2.00≤x<3.00; Good: 3.00 ≤ x < 4.00; Very good: 4.00≤x<5.00;							

Considering the average values of the boulevards' variables (V_1–V_5) and the Sidewalk Accessibility Index (SAI) created based on these values, Batı Gazi Boulevard has the highest SAI value. It is in the "Very good" category with a value of 4.05. The said boulevard draws attention, particularly with its V_3 (4.91) and V_1 (4.72) values. AtatürkBoulevard has the lowest SAI value (2.36) and offers "Fair" accessibility. Especially,V_4 (1.77) and V_5 (0.85) values are pretty low on Atatürk Boulevard, showing significant deficiencies on the sidewalk in terms of "effective width of the sidewalk (free area for movement)"and"intersections of urban streets–suitableness of street crossings (safe crossing)."

Concerning Variables (V_1–V_5), V_1 is high on all boulevards. Especially Hükümet (5.00)and Adnan Menderes (5.00) Boulevards received full points on this criterion.V_2, While Batı Gazi Boulevard comes to the fore with a V_2 value of 4.50, Atatürk Bulvarı has the lowest value of 2.17.V_3 is evenly distributed among all boulevards. Batı Gazi Boulevard has the highest value of 4.91, while the lowest value of 3.04 belongs to Adnan Menderes Boulevard.Whereas Adnan Menderes (4.93) andBatı Gazi (4.05) Boulevards have high V_4values, Atatürk (1.77) and İstasyon (2.60) Boulevards draw attention with their low values.V_5 displays low performance. Atatürk Boulevard has the lowest value (0.85), and Adnan Menderes Boulevard has the highest (2.68). This showsthe inadequacy of all boulevards in terms of "intersections of urban streets–suitableness of street crossings (safe crossing)" (Table 6).

Table 6. The average scores and SAI results for the boulevards are based on the various variables

Boulevards	V_1(Avg.)	V_2(Avg.)	V_3(Avg.)	V_4(Avg.)	V_5(Avg.)	SAI
Adnan Menderes	5.00	3.27	3.04	4.93	2.68	3.78
Atatürk	2.92	2.17	4.10	1.77	0.85	2.36
Batı Gazi	4.72	4.50	4.91	4.05	2.07	4.05
Doğu Gazi	4.49	3.19	4.23	3.07	1.54	3.31
Hükümet	5.00	3.54	4.76	3.58	2.18	3.81
İstasyon	4.77	3.24	3.94	2.60	1.25	3.16
Vali Konağı	4.24	3.57	4.78	2.68	2.09	3.47
Terrible: <1.00; Poor: 1.00≤x<2.00; Fair: 2.00≤x<3.00; Good: 3.00 ≤ x < 4.00; Very good: 4.00≤x<5.00; Excellent						

On Adnan Menderes Boulevard, both the east and west sidewalks were evaluated as "Good," and the general level of service was determined to be "C." Wheelchair users can move around this area with some difficulty. A similar situation applies to Doğu Gazi, Hükümet, İstasyon, and Vali Konağı Boulevards. The general level of service is also "C" on the above boulevards, and the sidewalks are in the "Good"category. This indicates that users may encounter limited difficulty when navigating. On Atatürk Boulevard, both the east and west sidewalks were evaluated as "Fair," and the level of service was shown as "D."

This boulevard has the lowest performance in terms of accessibility, and wheelchair users need assistance to move around. Batı Gazi Boulevard draws attention with the sidewalks in both directions being assessed as "Very good." This boulevard, with a general level of service of "B," stands out as the only route where wheelchair users can move around without obstacles (Table 7).

Table 7. The condition and accessibility of the sidewalks along the boulevards for wheelchair users

Boulevards	Sidewalk	Sidewalk	General	Level of	Description
Adnan Menderes	East	Good	Good	C	The wheelchair user can move around with some difficulty.
	West	Good			
Atatürk	East	Fair	Fair	D	The wheelchair user needs assistance to move around.
	West	Fair			
Batı Gazi	North	Very good	Very good	B	The wheelchair user can move around without obstacles.
	South	Very good			
Doğu Gazi	North	Good	Good	C	The wheelchair user can move around with some difficulty.
	South	Good			
Hükümet	East	Good	Good	C	The wheelchair user can move around with some difficulty.
	West	Good			
İstasyon	North	Fair	Good	C	The wheelchair user can move around with

	South	Good			some difficulty.
Vali Konağı	East	Good	Good	C	The wheelchair user can move around with some difficulty.
	West	Good			

Discussion:-

Sidewalks must provide comfort and safety conditions that meet the needs of all users, regardless of whether they have permanent or temporary physical limitations.[26-32]Sidewalks must be planned and managed according to a series of quality indices to ensure inclusive, safe, and attractive access to urban areas for all individuals.[33-35]

In line with the present research results, Batı Gazi Boulevard comes to the fore as the boulevard with the highest SAI value. While Adnan Menderes and Hükümet Boulevards have high SAI values, Atatürk Boulevard is in the "Fair" category. ANOVA results showed significant differences in SAI values among the boulevards. Whereas V_1 is high, V_5 has low values in all boulevards.

The V_5 value is especially low on Atatürk Boulevard.Batı Gazi Boulevard was determined to be the only route where wheelchair users could move around without obstacles. Atatürk Boulevard displays the lowest performance in terms of accessibility and is a boulevard where wheelchair users need assistance to move around. Wheelchair users can move around with some difficulty on other boulevards (Adnan Menderes, Doğu Gazi, Hükümet, İstasyon, and Vali Konağı Boulevards). Significant differences in accessibility levels were identified among the boulevards in Aydın Province. Whereas Batı Gazi Boulevard is in the best condition in terms of accessibility, Atatürk Boulevard should be improved. It is essential to increase accessibility standards on other boulevards and to ensure safe passages (V_5), in particular (Figure 3).

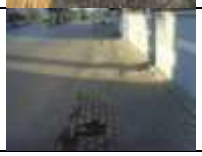
Point	Variables				
	V_1	V_2	V_3	V_4	V_5
Highest					
Lowest					

Figure 3. The sidewalks along the boulevards that have the variables with the highest and lowest scores

Atatürk Boulevard, Doğu Gazi Boulevard, and İstasyon Boulevard have the lowest SAI scores. This is primarily because of the sections of Atatürk Boulevard located south of Izmir Boulevard, Doğu Gazi Boulevard west of Müze Boulevard, and İstasyon Boulevard west of Körfez Street, all of which are in low socioeconomic neighborhoods. These findings show disparities in the availability of sidewalk construction, maintenance, and repair services.
The sidewalk along Batı Gazi Boulevard has the highest Level of Service (LS), rated as "B." In contrast, the sidewalk on Atatürk Boulevard has the lowest Level of Service, rated as "D."

Conclusion:-

This case study analyzed sidewalks and street crossings and found they had a "Good" accessibility level for wheelchair users, although some segments were in "Terrible" and "Poor"conditions."Unevenness between 5.0 and 10.0 cm in height, with or without concordance (steps)" in the Longitudinal Profile of the Sidewalk Surface (V_1) of Atatürk Boulevard and Doğu Gazi Boulevard and "Unevenness of more than 10 cm in height, with or without concordance (steps)" in the Longitudinal Profile of the Sidewalk Surface (V_1) of Atatürk Boulevard, Doğu Gazi Boulevard and İstasyon Boulevard should be reduced.

"Poor conditions (irregularities and deformations caused by tree roots)" on the Surface of the Sidewalk Pavement (V_2) of Adnan Menderes Boulevard, Atatürk Boulevard, Doğu Gazi Boulevard, Hükümet Boulevard, İstasyon Boulevard, and Vali Konağı Boulevard, and "Full of holes and loose stones, etc. (impracticable for use)" on the Surface of the Sidewalk Pavement (V_2) of Atatürk Boulevard, Batı Gazi Boulevard, Doğu Gazi Boulevard, İstasyon Boulevard, and Vali Konağı Boulevard should be repaired.Pietrucha et al[19,36]stated in their study that sidewalks should be kept in good condition, free from cracks and rough surfaces.

Continuity in the sidewalks should be maintained by removing the interruptions in the segments marked as "No pavement or vegetal covering (grass)" in the Materials Used for the Sidewalk Pavement (V_3) of Atatürk Boulevard, Doğu Gazi Boulevard, and İstasyon Boulevard.On all seven boulevards, the obstacles in the Effective Width of the Sidewalk (V_4) marked "Free area width around 0.80 m. Obstructions impair wheelchairs' movement" should be removed, and the sidewalk should be widened. The obstacles in the Effective Width of the Sidewalk (V_4) of Atatürk Boulevard, Doğu Gazi Boulevard, and İstasyon Boulevard, "Sidewalk totally obstructed / no sidewalk. Impossible wheelchair movement" should be removed to ensure wheelchair users' passage on the sidewalk.According to Pietrucha et al.[19], sidewalks should be continuous and built to specified widths, ensuring that street furniture and other accessories are excluded from the walking path. Discontinuous sidewalks can lead to issues with pedestrian access and safety. Street furniture should be placed outside the usual walking path on the sidewalk to avoid blocking pedestrians. This is especially important for wheelchair users and visually impaired pedestrians.

In the Intersections of Urban Streets (V_5) of 6 out of the seven examined boulevards (Atatürk Boulevard, Batı Gazi Boulevard, Doğu Gazi Boulevard, Hükümet Boulevard, İstasyon Boulevard, and Vali Konağı Boulevard), "Inadequate intersections, without ramps, without zebra crossing, and without traffic lights" should be improved. Pedestrian crossings need to be striped, and traffic lights should be timed.Wanita and dan Masyarakat[18]suggested prioritizing crossings that improve safety and accessibility for vulnerable pedestrians, such as children, individuals with disabilities, and patients.

The current study offers valuable insights into creating a more inclusive and accessible city by identifying areas that require improvement in terms of urban planning and design. The research contributes to global science, as its method is a case study, and it emphasizes the importance of prioritizing sidewalks in cities. Hence, it can be a reference for future research to be conducted in other cities on the quality and accessibility of sidewalks using the same approach.

Authors' contribution
All authors contributed equally to the research study/project.

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ORCID iDs
Barış KARA https://orcid.org/0000-0002-5670-8636
Özlem Kazmacı https://orcid.org/0009-0001-8089-6163
Buse Ar https://orcid.org/0000-0002-9230-8226
Cansu Aykan https://orcid.org/0009-0009-6288-4845
Ayşanur Bayram https://orcid.org/0000-0002-0642-0626
Sezen Özçetin https://orcid.org/0009-0003-9266-8330
Özgür Özsoy https://orcid.org/0000-0002-3780-9706
Melike Yaman –

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