# Examining the Accessibility of Sidewalks for Wheelchair Users: The Case of EfelerCity (Aydın/Türkiye)


## Abstract

The boulevards with the highest mean score for variable 1 ($V_1$) (5.00/Excellent) are Adnan Menderes Boulevard andHükümetBoulevard;the boulevard with the highest mean scores for $V_2$and $V_3$ (4.50 and 4.91, respectively/Very good) isBatıGazi 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) isBatıGaziBoulevard. The Level of Service (LS) of BatıGaziBoulevard's sidewalks is "B.""The wheelchair user can move around without obstacles" on BatıGazi Boulevard's sidewalks.

This study examined the accessibility of the sidewalks of the boulevards in the city center of 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.



Keywords: Sidewalk assessment, sidewalk accessibility index,sidewalk quality index, disability, wheelchair users


## Introduction

Mobility, which is defined as the ability to walk in a safe and independent manner, represents a critical requirement for carrying out activities of daily living.[1] As showed by,[2]a mobility impairment in walkingis related to difficulty walking. A mobility impairment can be congenital or gained,[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'rebeing dangerous.

Accessibility features directly impact a sidewalk's usability.[6]Many sidewalks are not wheelchair-friendly. Changes in 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 difficult 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]

Many studies have been conducted in the literature on the factors and obstacles impacting 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 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 maintenanceas 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 showed a strong correlation between the surface roughness values calculated using the suggested method and discomfort given 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 presented a method to assess performing sidewalks and street crossings, aiming to identify accessible routes in cities based on wheelchair users' expectations and needs. The method in question addresses the variables defining comfort and safety aspects for wheelchair users by weighting them. The aim of this article is to assess the sidewalk quality level and accessibility of the city of Efeler (Aydın/Türkiye).

## Materials and Methods

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 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 wide applicability of the current method. Using the scientific multi-criteria method fills a gap in the literature, which has approached the subject with simpler models to date. The method's output is simple, which makes it easier for decision-makers to get an overview of the sidewalk network and to assess opportunities for improvement.

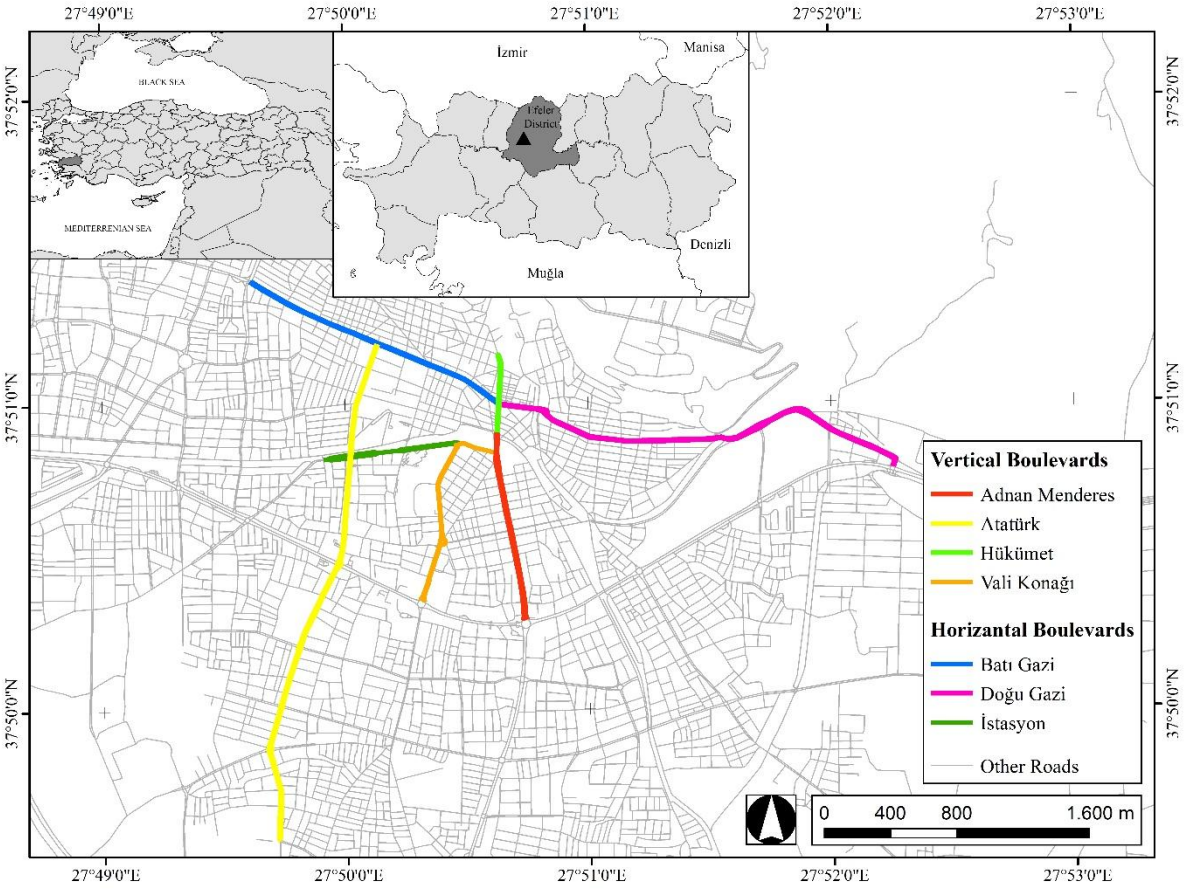


Figure 1. Study area

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. Sidewalks'assessment variables, related descriptions, and scores[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 got through equation (1),
$SAI = [V_1(Avg.) + V_2(Avg.) + V_3(Avg.) + V_4(Avg.) + V_5(Avg.)]/5$ (Equation 1)

Table 3. Sidewalk Accessibility Index (SAI) and Level of Service (LS)[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 İstasyonBoulevard; 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. Characteristics of the studied boulevards in Aydın

| **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 | |
| BatıGazi | Horizontal | North | 23 | 15 | 1677.40 |
| | | South | 40 | 15 | |
| DoğuGazi | 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 distributing 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 quite 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 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 wide. This

suggests that the west sidewalk has inconsistent accessibility standards.Both the north and south sidewalks of BatıGaziBoulevard have high SAI values.It draws a very successful profile regarding accessibility because of the narrow distribution. Both the north and south sidewalks on DoğuGaziBoulevard have variable accessibility. Low extreme values show that significant accessibility problems may occur on these sidewalks.The SAI values on İstasyonBoulevard are at the"Good"level (~3.5), the distribution is wide, 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 BatıGazi Boulevards have the highest averages, Atatürk, DoğuGazi, and İstasyon Boulevards display the lowest values (Figure 2).

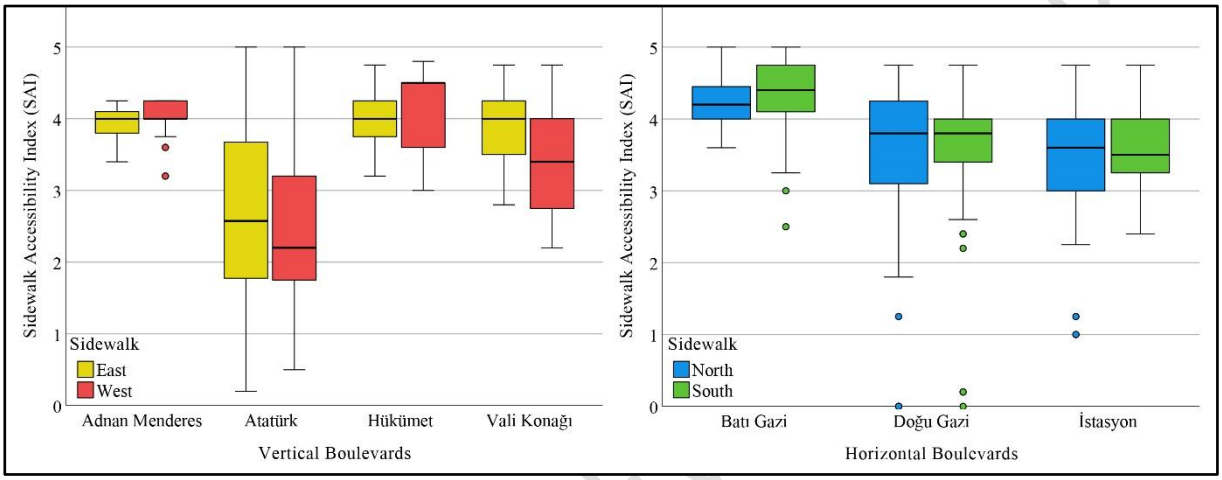


Figure 2. Boxplot diagrams of the Sidewalk Accessibility Index (SAI) by segments of Aydın boulevards ($F_{Boulevards}$=31.394, $p$=0.000; $F_{Sidewalk}$=1.085, $p$=0.355)

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 BatıGazi 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 with 4.09, especially on the south sidewalk of BatıGazi Boulevard. Major imbalances between the variables in 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 quite 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 reveals areas that should be improved in terms of urban planning.

Table 5. The average values of the sidewalks' variables 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 |
| BatıGazi | 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 |
| DoğuGazi | 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; Excellent: =5.00; SAI: Sidewalk Accessibility Index

Considering the average values of the boulevards' variables ($V_1$–$V_5$) and the Sidewalk Accessibility Index (SAI) created based on these values, BatıGazi Boulevard has the highest SAI value and 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 quite 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. EspeciallyHükümet (5.00)and Adnan Menderes (5.00) Boulevards received full points on this criterion.$V_2$, While BatıGaziBoulevard comes to the fore with a $V_2$ value of 4.50, Atatürk Bulvarıhas the lowest value of 2.17.$V_3$ is evenly distributed among all boulevards. BatıGazi 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) andBatıGazi (4.05) Boulevards have high$V_4$ values, Atatürk (1.77) andİstasyon (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 shows inadequacy of all boulevards in terms of "intersections of urban streets–suitableness of street crossings (safe crossing)" (Table 6).

Table 6. The boulevards' average scores according to the 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 |
| BatıGazi | 4.72 | 4.50 | 4.91 | 4.05 | 2.07 | 4.05 |
| DoğuGazi | 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: =5.00; SAI: Sidewalk Accessibility Index

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 DoğuGazi, 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 shows that users may face limited difficulties when moving around. On Atatürk Boulevard, both the east and west sidewalks were evaluated as "Fair," and the level of service was showed as "D." This boulevard has the lowest performance in terms of accessibility, and wheelchair users need assistance to move around. BatıGazi 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. Accessibility levels of the boulevards' sidewalks for wheelchair users

| **Boulevards** | **Sidewalk** | **Sidewalk Condition** | **General Condition** | **Level of Service** | **Description** |
|---|---|---|---|---|---|

| | | | | | |
|---|---|---|---|---|---|
| Adnan Menderes | East<br>West | Good<br>Good | Good | C | The wheelchair user can move around with some difficulty. |
| Atatürk | East<br>West | Fair<br>Fair | Fair | D | The wheelchair user needs assistance to move around. |
| BatıGazi | North<br>South | Very good<br>Very good | Very good | B | The wheelchair user can move around without obstacles. |
| DoğuGazi | North<br>South | Good<br>Good | Good | C | The wheelchair user can move around with some difficulty. |
| Hükümet | East<br>West | Good<br>Good | Good | C | The wheelchair user can move around with some difficulty. |
| İstasyon | North<br>South | Fair<br>Good | Good | C | The wheelchair user can move around with some difficulty. |
| Vali Konağı | East<br>West | Good<br>Good | Good | C | The wheelchair user can move around with some difficulty. |

**Discussion and Conclusion**

Sidewalks must provide comfort and safety conditions that meet all users' needs, regardless of 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, BatıGaziBoulevard comes to the fore as the boulevard with the highest SAI value. While Adnan Menderes andHükümetBoulevards have high SAI values, Atatürk Boulevard is in the "Fair" category. ANOVA results showed significant differences in SAI values among the boulevards. Whereas V1 is high, $V_5$ has low values in all boulevards. The $V_5$value is especially low on Atatürk Boulevard.BatıGazi 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, DoğuGazi, Hükümet, İstasyon, and Vali Konağı Boulevards). Significant differences in accessibility levels were identified among the boulevards in Aydın Province. Whereas BatıGazi 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).

Figure 3. Boulevard that has variables with the highest and lowest scores

| Point | Variables | | | | |
|---|---|---|---|---|---|
| | $V_1$ | $V_2$ | $V_3$ | $V_4$ | $V_5$ |
| Highest |  |  |  |  |  |
| Lowest |  |  |  |  |  |

Reuter[36] stated that sidewalks should be kept in good condition, free of cracks and rough surfaces.Wanitaand dan Masyarakat[18]recommended that priority be given to crossings where vulnerable pedestrians, such as children, sick persons, or individuals with disabilities, will benefit from improved safety and accessibility.

The current study provides important information on creating a more inclusive and accessible city by identifying areas that should be improved in terms of urban planning and design. The research contributes to global science since its method is the case study and it stresses prizing 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.

**Declaration of Conflicting Interests**

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

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**References**

1. Shumway-Cook A and Woollacot M. Motor control, Theory and practical applications, 1st Edition, Baltimore, MD: Williams and Wilkins 1995

2. Clarke P, Alshire JA and Lantz P. Urban built environments and trajectories of mobility disability: Findings from a national sample of communitydwelling American adults (1986–2001). *Social Science and Medicine* 2009; 69(6): 964-970.

3. Disabled World News. Definition of disability including types of disabilities and the social model of disabilities: Available at: http://www.disabledworld. com/disability/types [Accessed 10 May 2025]

4. Clarke PJ, Lawrence JM and Black SE. Changes in quality of life over the first year after stroke: Findings from the Sunnybrook stroke study. *Journal of Stroke & Cerebrovascular Diseases* 2000; 9 (3): 121-127.

5. Clarke P, Marshall VW, Black SE and Colantonio A. Well-being following stroke in Canadian seniors: Findings from Canadian Study of Health and Aging. *Stroke* 2002; 33(4): 1016-1021.

6. Axelson PW, Chesney DA, Galvan DV, Kirschbaum JB, Longmuir PE, Lyons C, Wong KM, Designing sidewalks and trails for access Part I of II: Review of Existing Guidelines and Practices. Program Manager: Barbara McMillen, July 1999a.

7. Wey MW and Chiu YH. Assessing the walkability of pedestrian environment under trasit-oriented development. *Habitat International* 2013; 38: 106-118.

8. Tsiompras AB and Photis YN. What matters when it comes to "Walk and the city"? Defining a weighted GIS-based walkability index. *Transportation Research Procedia* 2016; 24: 523-530.

9. Sousa N, Coutinho-Rodrigues J and Natividade-Jesus E. (2017). Sidewalk infrastructure assessment using a multicriteria methodology for maintenance planning. *Journal of Infrastructure Systems* 2017; 23(4): 05017002.

10. Brown BB, Werner CM, Amburgey JW and Szalay C. Walkable Route Percept ions and Physical Features. Environment and Behavior 2007: 39(1): 34-61.

11. Litman T. Evaluating accessibility of transport planning: Measuring people's ability to reach desired goods and services. Victoria Transport Policy Institute 2019.

12. da Rocha VT, Brandli LL, Locatelli Kalil RM, Salvia AL and Prietto PDM. Quality of sidewalks in a Brazilian city. *Theoretical and Empirical Researches in Urban Management* 2019; 14(2): 41-58.

13. Ferreira MAG and Sanches SP. Proposal of a sidewalk accessibility index. *Journal of Urban and Environmental Engineering* 2007; 1(1): 1-9.

14. Axelson PW, Wong KM and Kirschbaum JB. Development of an assessment process to evaluate sidewalk accessibility. *78th Annual Meeting of the Transportation Research Board* 1999b; Transportation Research Board, Washington, DC.

15. Ishida T, Takemoto H, Ishida S, Kameyama S, Himeno K and Kashima S. Evaluation of sidewalk unevenness based on wheelchair traveling resistance. *Transportation Research Record: Journal of the Transportation Research Board*2006; 1956(1): 68-75.

16. U.S. Access Board - U.S. Architectural and Transportation Barriers Compliance Board. Bulletin #4: Surfaces 1994; 1-8: Washington.

17. Rocchi S and Bathurst C. District of north Vancouver pedestrian master plan final report, *Opus International Consultants (BC) Ltd*. 2009.

18. Wanita KP and danMasyarakat K. A review of international best practice in accessible public transportation for persons with disabilities. *UNDP* 2010; Malaysia.

19. Pietrucha MT, Opiela KS and Plummer CW. Pedestrians with disabilities. *Institute of Transportation Engineers, Technical Council Committee 5A-5. Design and safety of pedestrian facilities* 1998; Chair: Charles V. Zeeger.

20. Kockelman K, Heard L, Kweon YJ and Rioux TW. The Nature of ADA's sidewalk cross-slopes requirements: A review of the literature. *Proc. 79th Annual Meeting of the Transportation Research Board* 2000; CD-ROM, Washington D.C.

21. Oeda Y and Sumi T. Wheelchair user perception of road roughness. *Proc. 26th Australasian Transport Research Forum* 2003; CD-ROM, Wellington, New Zealand.

22. Evans-Cowley J. Sidewalk planning and policies in small cities. *J. Urban Plann Dev* 2006; 132(2): 71–75.

23. Nitsch Engineering Stantec Pedestrian Accessibility Study. Medford, Massachusetts, June 2021

24. The Republic of Türkiye Ministry of Family and Social Services. Disabled and elderly statistics bulletin. January 2022. https://www.aile.gov.tr/media/98625/eyhgm_istatistik_bulteni_ocak_2022.pdf. (Accessed: 01.05.2025)

25. Barrier-Free Living Association - Ey-Der. Disabled people in Türkiye and the world. https://ey-der.com/ana-sayfa/turkiye-ve-dunyada-engelliler/ (Accessed: 28.02.2025).

26. Fruin JJ. Pedestrian planning and design. *Metropolitan Association of Urban Designers* 1987; New York.

27. Khisty CJ. Evaluation of pedestrian facilities: Beyond the level-of-service concept. *Journal of the Transp. Res. Board* 1994; 1438, 45-50.

28. Sarkar S. Evaluation of different types of pedestrian-vehicle separations. *Proc. Transportation Research Record. Journal of the Transp. Res. Board* 1995; 1502: 83-95.

29. FHWA – Federal Highway Administration. Designing sidewalks and trails for access - Part 1 - Chapter 4a – Sidewalk Design Guidelines and Existing Practices 1999.

30. Ferreira MAG and Sanches SP. Índice de Qualidade das Calçadas – IQC. *Revista dos TransportesPúblicosANTP* 2001; 91: 47- 60.

31. Ferreira MAG and Sanches SP. Rotasacessíveis: Formulação de um índice de acessibilidade das calçadas. *Proc. XV Congresso Nacional de TransportesPúblicos* 2005; Goiânia, GO.

32. Rakesh K. Evaluation of the pedestrian environment – A Qualitative approach – Case study of Theagaraya Nagar – the commercial hub of Chennai city, TRB 2007 Annual Meeting 2007.

33. Bradshaw C. Using our feet to reduce our footprint: The importance of scale in life. *Local Environment. The International Journal of Justice and Sustainability* 1997; 2(1): 89-94.

34. Kamel MAE. Encouraging walkability in GCC cities: smart urban solutions. *Smart and Sustainable Built Environment* 2013; 2(3): 228-310.

35. Speck J. Walkable city: how downtown can save America, one step at a time. New York: North Point Press. 2013.

36. Reuter RC. Pedestrians with disabilities. *Institute of Transportation Engineers, Technical Council Committee 5A-5. Design and safety of pedestrian facilities* 1998; Chair: Charles V. Zeeger.