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IoT-Based Pedestrian Performance Evaluation at Tegar Beriman Street

Syaiful Syaiful[1], Azhar Aswatdinata[2], Muhamad Lutfi[3], Nurul Chayati[3], Asri Kusuma Wardhani[4]

[1]Professor in the Civil Engineering Department at Ibn Khaldun University Bogor, INDONESIA
[2]Student in the Civil Engineering Department at Ibn Khaldun University, Bogor, INDONESIA
[3]Civil Engineering Department at Ibn Khaldun University, Bogor, INDONESIA
[4]Student at Civil Engineering Departement at Narotama University Surabaya, INDONESIA

E-mail: azharaswatdinata70@gmail.com

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ABSTRACT

A human-oriented urban environment prioritizes pedestrians, with scale and proportions tailored to human activities. This study aims to evaluate pedestrian performance in front of the PDAM TK, Tegar Beriman Street, Bogor Regency, through an Internet of Things (IoT)-based transportation engineering approach. Tegar Beriman Street is a primary urban corridor connecting various public facilities; therefore, the availability of safe, comfortable, and accessible pedestrian infrastructure is essential. However, preliminary observations revealed significant variations in pedestrian conditions, including inconsistent sidewalk widths, pavement materials, vegetation arrangements, and supporting amenities. This research employed direct observation, IoT-assisted monitoring, and literature review to collect both primary and secondary data. Primary data were obtained through field surveys, including pedestrian volume counts, documentation of existing conditions, geometric measurements of sidewalks, and inventory of pedestrian facilities. In addition, IoT technologies such as smart sensors, CCTV-based monitoring, and digital traffic counting systems were recommended to improve the accuracy and efficiency of pedestrian performance evaluation. Secondary data were collected from relevant transportation engineering standards and technical guidelines. The results indicate that the existing pedestrian facilities do not fully comply with established standards for pedestrian safety and accessibility. Several deficiencies were identified, including inadequate facilities for persons with disabilities, inconsistent road markings, ineffective traffic signs, and insufficient supporting amenities such as lighting systems, waiting areas, waste bins, and smart crossing facilities. Furthermore, the absence of real-time pedestrian monitoring limits the effectiveness of traffic management and pedestrian safety analysis.

Keywords: IoT, pedestrian evaluation, pedestrian facilities, existing conditions.

INTRODUCTION

A human-oriented urban environment places pedestrians as the top priority, considering scale and proportion appropriate to human activities. Pedestrians are a vital element in urban life, connecting various locations through dedicated paths like sidewalks. To improve the quality of life in urban areas, the development of comprehensive pedestrian zones is a necessity. Providing adequate pedestrian infrastructure, especially in activity centers, will create a more humane environment, supporting social, economic, and cultural activities of the community. Which requires the provision of adequate pedestrian facilities, including for persons with disabilities, on every public road. In Indonesia, pedestrians have a strategic role in supporting community mobility [1]. User comfort and safety are the top priorities in designing pedestrian paths. Tegar Beriman Street in Bogor Regency, as one of the main arterial roads, connects various important public facilities and is a center of community activities. However, initial observations show significant differences in pedestrian conditions along this road, especially in front of PDAM Tirta Kahuripan (TK), regarding sidewalk width, materials, vegetation, and provided facilities.

This study aims to evaluate pedestrian performance in front of PDAM TK, Tegar Beriman Street, Bogor Regency [2]. This evaluation is expected to provide input for improving pedestrian services,

facilitating access to public transportation, and providing solutions to existing problems. This research focuses on the pedestrian area in front of PDAM TK, with the aim of obtaining an overview of existing conditions and assessing their conformity with applicable standards, so that it can provide useful policy recommendations. Various studies have been conducted to evaluate the condition and performance of pedestrian facilities in various regions of Indonesia, highlighting the importance of providing safe, comfortable, and standardized infrastructure [3]. Research in Bengkulu City found the need for expansion and development of pedestrian zones, as well as improvements in intersection design to enhance pedestrian comfort on WR Supratman Street [4]. Research by Panji emphasized the importance of separating pedestrian paths from vehicle lanes, providing transition spaces, and paying attention to sidewalk dimensions to avoid conflicts between road users [5].

Pedestrian evaluation in Semarang City by Baju showed that although sidewalk width dimensions largely met standards, problems arose due to lane narrowing by building entrance openings and non-compliance of sidewalk height with applicable standards [6, 7]. Research by Ainon also found non-compliance with standards in terms of materials, maintenance conditions, and availability of pedestrian network facilities [8].

Highlights the importance of integrating IoT technology into pedestrian infrastructure management to support data-driven transportation planning and smart city development [9, 10]. Therefore, the study recommends that the local government implement IoT-based pedestrian monitoring systems, improve pedestrian infrastructure, strengthen traffic regulation enforcement, and encourage community participation in the planning and maintenance of pedestrian facilities to create a safer, smarter, and more inclusive urban pedestrian environment [11-13].

Transportation and pedestrians are closely related at intersections because intersections are points where vehicle movement and pedestrian movement interact directly. Pedestrians use intersections to cross roads safely and access public facilities, commercial areas, public transportation, and other urban activities. Therefore, intersections play an important role in supporting mobility, accessibility, and traffic safety within transportation systems [15-17].

In transportation engineering, pedestrian facilities at intersections include sidewalks, zebra crossings, pedestrian signals, waiting areas, and accessibility features for disabled users. Proper pedestrian management helps reduce conflicts between vehicles and pedestrians, minimizes accident risks, and improves traffic flow efficiency. Poorly designed intersections may cause congestion, unsafe crossing behavior, and reduced pedestrian comfort [18-20].

The increasing number of vehicles in urban areas often creates challenges for pedestrian safety at intersections. As a result, transportation planning must prioritize human-oriented design by providing safe, comfortable, and accessible pedestrian infrastructure. Modern transportation systems also integrate smart technologies such as Internet of Things (IoT)-based sensors, CCTV monitoring, and smart traffic signals to improve pedestrian safety and operational performance. Thus, effective intersection management supports sustainable urban transportation and enhances the quality of life for pedestrians in urban environments.

RESEARCH METHODS

Materials

This study evaluates the pedestrian conditions on Tegar Beriman Street, through field observations to collect existing data on pedestrian conditions and facilities. Secondary data is collected through literature review, as the main reference for assessing compliance with standards [2].

The following is shown in Figure 1 below, the framework of thought and research flowchart.

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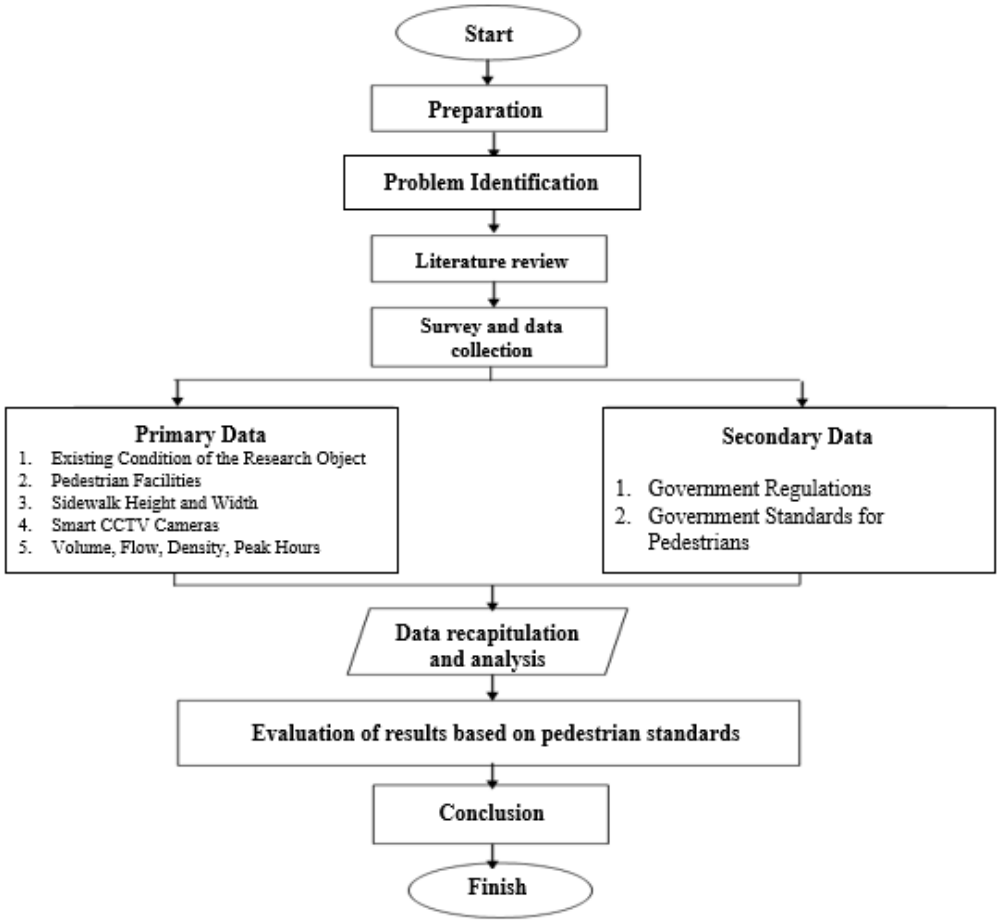

Figure 1. Flow chart

Place and time of research

This study evaluates pedestrian conditions in front of PDAM TK, Tegar Beriman Street, Bogor Regency, from January to February 2025, focusing on the afternoon rush hours (17:00-19:00) to observe pedestrian activities and assess infrastructure compliance [2].

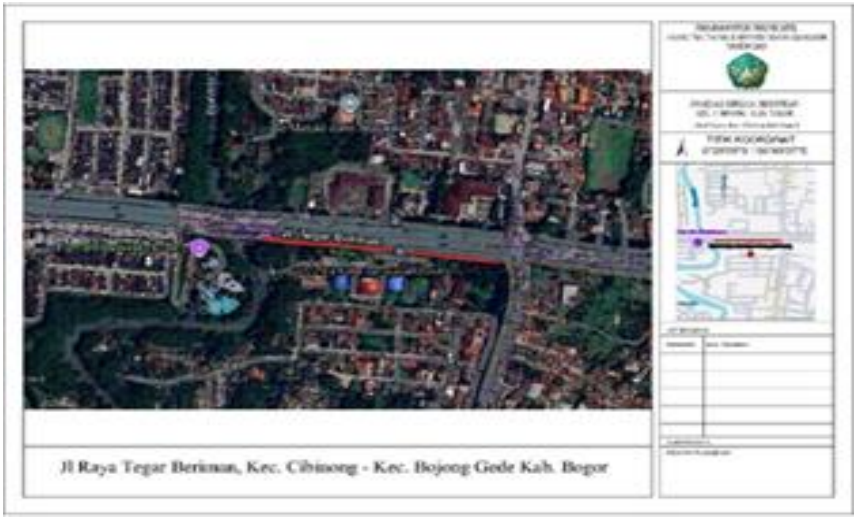

Figure 2. Research Location [14]

Methods

This study employs two primary data collection methods: direct observation and literature review. Direct observation is conducted to gather existing data on pedestrian conditions and facilities, with photographic documentation as supporting evidence. Literature review is used to collect secondary data from relevant sources, which serves as the main reference for this research [2].

This study used a quantitative descriptive approach to evaluate pedestrian performance in front of the PDAM Tirta Kahuripan Cibinong Branch on Tegar Beriman Street, Bogor Regency, using an Internet of Things (IoT)-based monitoring approach. The research was conducted through field observation, pedestrian traffic surveys, and smart sensor monitoring.

Primary data were collected by direct observation of pedestrian facilities, including sidewalk width, pavement condition, accessibility, lighting, signage, and supporting amenities. Pedestrian volume and movement characteristics were measured using IoT devices such as smart CCTV cameras, pedestrian counters, and motion sensors installed at selected observation points. The IoT system enabled real-time monitoring and automatic recording of pedestrian flow data.

Secondary data were obtained from transportation engineering standards, pedestrian facility guidelines, journals, and related government regulations. The collected data were analyzed descriptively by comparing existing pedestrian conditions with established pedestrian facility standards and Level of Service (LOS) criteria. The evaluation focused on pedestrian safety, comfort, accessibility, and operational performance. The results were then used to formulate recommendations for improving pedestrian infrastructure and implementing IoT-based smart pedestrian management systems in urban transportation corridors.

RESULTS AND DISCUSSION

Analysis Results of Pedestrian Facilities

1. Sidewalks and crossings, observations indicate that sidewalks and crossings in front of PDAM TK lack facilities for pedestrians with special needs [2]. A comprehensive evaluation is necessary to ensure inclusive facilities for all road users, including persons with disabilities.
2. Road markings, the zebra crossing road markings at the PDAM TK traffic light intersection do not meet the standards specified [2].
3. Traffic signs, traffic signs in pedestrian areas must be strategically placed, meet specifications, and be accessible to all. However, in front of PDAM TK, the "no stopping" signs are ineffective due to persistent vehicle parking. This ineffectiveness is due to a lack of law enforcement, low road user awareness, and potentially unclear sign designs.
4. Waiting areas, mandate the provision of waiting areas in public spaces as rest areas for pedestrians. However, in front of PDAM TK, these facilities are absent, potentially reducing pedestrian comfort and safety, especially for the elderly and persons with disabilities. Local governments need to promptly provide standardized waiting areas in strategic locations, with comfortable and accessible designs for all users [2].
5. Safety lighting, require the installation of pedestrian street lighting every 10 meters with a maximum height of 4 meters, using durable materials. However, in front of PDAM TK, there are no streetlights at all, violating the guideline standards. This lack of lighting poses safety risks for pedestrians, especially at night, and creates a sense of insecurity. Local governments need to promptly install standardized lighting to ensure pedestrian safety and comfort [2].
6. Safety barriers, the standard for safety barriers in pedestrian lanes is 90 cm high, made of weather-resistant and easily maintained materials, designed to protect pedestrians from traffic hazards. However, in front of PDAM TK, there are no safety barriers, posing a high risk to pedestrian safety. Local governments need to promptly install standardized safety barriers in strategic locations with durable materials.
7. Green belts, the guidelines specify a minimum green belt width of 1.20 meters. In front of PDAM TK, the green belt width is 1.7 meters, exceeding the standard. While not a violation, it is necessary to evaluate whether this excess width is optimal or reduces space for other pedestrian facilities.

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8. Seating, according to the guidelines, seating in pedestrian facilities should be spaced 110-120 meters apart, with dimensions of 40-50 cm wide, 120 cm long, and 35-40 cm high, using durable materials. However, in front of PDAM TK, there is no seating, which does not comply with the guidelines. This reduces comfort and accessibility, especially for vulnerable groups, and diminishes pedestrian potential. An evaluation and addition of seating according to the guidelines is needed to improve the quality of pedestrian facilities.
9. Trash cans, according to the guidelines, trash cans should be placed every 20 meters or at intersections, using durable materials and a maximum height of 90 cm. However, in front of PDAM TK, there are no trash cans, violating the guidelines. The absence of trash cans causes cleanliness and health problems and reduces pedestrian comfort. Prompt addition of trash cans according to the guidelines is needed to create a clean and healthy environment.
10. Bus stops, should be placed within a radius of 200-1.000 meters or at potential points. However, in front of PDAM TK, there are no bus stops, which does not comply with the guidelines. The absence of bus stops reduces public transportation accessibility and passenger comfort. An evaluation and addition of bus stops according to the guidelines is needed to improve the quality of pedestrian and public transportation facilities.
11. Shelter/shade, emphasize the importance of shelter/shade and green belts for pedestrian comfort and safety. In front of PDAM TK, the presence of a 1.7meter wide green belt complies with the guidelines, functioning as water absorption, heat resistance, and lane separation. The presence of these elements demonstrates a commitment to the guidelines to create a safe, comfortable, and sustainable pedestrian environment.

Minimum pedestrian requirements

Tegar Beriman Street functions as a primary arterial road, connecting essential points and national roads. A primary arterial road ideally has a fenced sidewalk, at-grade crossings, and complete supporting facilities. However, observations in front of PDAM TK indicate only the presence of sidewalks, signs, and markings, thus not yet in accordance with these guidelines [2].

The results of the field survey indicate that pedestrian facilities in front of the PDAM TK have not fully met urban pedestrian service standards. Several sidewalk sections showed inconsistent widths, damaged pavement surfaces, limited accessibility for disabled pedestrians, and inadequate supporting facilities such as lighting, benches, waste bins, and pedestrian signs. These conditions reduced pedestrian comfort and safety, especially during peak traffic periods. The IoT-based pedestrian monitoring system successfully recorded pedestrian movement, pedestrian volume, and crossing activities in real time. Smart CCTV cameras and pedestrian sensors identified fluctuations in pedestrian flow during morning and afternoon peak hours, particularly near public service access points and roadside commercial activities. The monitoring results showed that pedestrian density increased significantly during office operating hours, creating conflicts between pedestrians and vehicles due to limited crossing facilities and sidewalk obstructions. The analysis also revealed that several pedestrians preferred walking on the roadway instead of using the sidewalk because of poor sidewalk conditions and the presence of parked motorcycles or street vendors. This situation increased the risk of traffic accidents and reduced the operational performance of the pedestrian corridor. Based on pedestrian Level of Service (LOS) evaluation, the study area was categorized as moderate to poor pedestrian service quality in several observation segments. The implementation of IoT technology provided significant support for transportation engineering analysis by improving the accuracy and efficiency of pedestrian data collection. Real-time monitoring enabled better identification of pedestrian behavior patterns, congestion points, and safety issues. Furthermore, IoT technology can support smart city transportation systems through continuous monitoring, data integration, and faster decision-making for pedestrian infrastructure management.

Table 1. Minimum Pedestrian Facility Requirements Availability

No	Minimum Requirements	Accessibility	
		Yes	No
1	Sidewalks with fencing and access to crosswalks and bus shelters		√

No	Minimum Requirements	Accessibility	
		Yes	No
2	At-grade crossing	√	
3	Signs	√	
4	Markings	√	
5	Traffic Light		√
6	Lighting		√
7	Bus stop		√

Sidewalk height

Field observations conducted in front of the PDAM TK revealed a sidewalk height of 19 cm. The recommended sidewalk height for arterial or collector roads with high traffic volumes is 15-20 cm. Therefore, the sidewalk height at the study location aligns with the established standards [2].

Figure 3. Sidewalk height Source: personal documentation 2025

Pedestrian width

Observations conducted in front of the PDAM TK revealed a sidewalk width of 200 cm. The minimum effective width for two wheelchair users or two adults to pass each other is 185 cm. Therefore, the sidewalk width at the study location meets the standard for the effective width of a pedestrian pathway [2].

Figure 4. Pedestrian width Source: personal documentation 2025

Improvements are required in sidewalk design, accessibility facilities, pedestrian crossings, lighting systems, and enforcement of sidewalk usage regulations. The integration of IoT-based monitoring systems is also recommended to support sustainable, safe, and intelligent pedestrian transportation management in Bogor Regency

CONCLUSION

The condition of pedestrian facilities in front of PDAM TK, particularly in terms of facilities for pedestrians with special needs and the completeness of supporting facilities. The evaluation shows non-compliance with the guidelines, with significant deficiencies in accessibility and safety, including the unavailability of pedestrian paths for persons with disabilities, standard-compliant road markings, effective signs, and other supporting facilities. Local governments should promptly evaluate and improve pedestrian infrastructure according to standards, including accessibility for

persons with disabilities. Enforcement of traffic violations and public awareness campaigns on traffic sign compliance need to be enhanced. Engage the community in planning, conduct routine monitoring, and prioritize supporting facilities like lighting and seating. Further research is needed for a deeper understanding. The pedestrian facilities on Tegar Beriman Street in front of the PDAM TK have not fully met safety, comfort, and accessibility standards. The implementation of IoT-based monitoring systems helps improve pedestrian data collection, traffic analysis, and transportation management. Infrastructure improvement and smart pedestrian facility development are needed to create a safer, more efficient, and sustainable urban pedestrian environment.

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