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Analysis of Pedestrian Infrastructure and Pedestrian Level of Service (PLOS) Based on User Perception (Case Study of Kombespol Street, Lamongan Regency)

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Abstract. Pedestrian infrastructure supports safe, comfortable, and sustainable urban mobility. Kombespol Street in Lamongan Regency, located in the city center, serves commercial, office, educational, and public facility activities with substantial pedestrian movement. This study evaluated the technical condition of the pedestrian infrastructure, determined the Pedestrian Level of Service (PLOS), and assessed user perceptions of sidewalk quality. A descriptive quantitative approach combined field observation, geometric measurements, pedestrian counts, and questionnaires from 50 respondents selected by accidental sampling. PLOS was evaluated using the Highway Capacity Manual (HCM, 2000) approach. The peak volume of 38 people over an effective area of 50 m² gave a density of 0.76 people/m² and a pedestrian space of 1.32 m²/person, corresponding to LOS E. User perception was fair to poor, with the lowest ratings for water puddles, drainage performance, side obstacles, and accessibility. Pavement repair, drainage improvement, obstacle control, and better accessibility facilities are required.

Keywords: Kombespol Street, pedestrian infrastructure, Pedestrian Level of Service, sidewalk, user perception

1. Introduction

Pedestrian infrastructure development in recent decades has experienced a significant paradigm shift. If urban planning was previously more oriented toward motorized vehicles, current approaches increasingly place humans at the center of planning. In this context, pedestrian infrastructure is not merely a complementary element but an important component of sustainable, inclusive, and healthy urban development. Walkability has therefore become an important indicator in evaluating the quality and sustainability of urban areas [1].

Pedestrians are the most basic mode of transportation in an urban transportation system. Every trip, whether made by private vehicle or public transportation, begins and ends with walking. Consequently, the quality of pedestrian infrastructure affects the effectiveness of the transportation

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system as a whole. Walking has an average speed of approximately 3-4 km/h and is particularly important for short-distance travel in active city-center areas [2].

From a civil engineering perspective, sidewalks must be designed by considering structural strength, pavement durability, subgrade stability, drainage, and appropriate surface slopes. Sidewalk pavement distributes loads to the underlying layers while providing a flat and safe walking surface. Inadequate structural or drainage performance can cause cracks, local settlement, ponding, and reduced service life [3].

Previous research has shown that sidewalk physical quality is closely related to pedestrian comfort and safety. Hamdani [4] identified inadequate dimensions, pavement damage, and insufficient supporting facilities as factors that reduce pedestrian service quality. Similarly, Lubis et al. [2] reported that uneven surfaces and interference with pedestrian movement affect users' perceptions of comfort. User perception is also important because pedestrian comfort is not determined only by objective physical conditions but also by the experience formed through interaction with the surrounding environment [4], [5], [1].

In quantitative evaluation, Pedestrian Level of Service (PLOS) is used to assess pedestrian service based on movement space, density, and pedestrian interaction. PLOS classifies service from level A to F, ranging from very free movement to highly congested and unstable conditions [6], [7]. Its application in Indonesian urban contexts also needs to consider local characteristics [1], [8].

Lamongan Regency is a lowland area with relatively high rainfall. This condition increases the importance of an adequate sidewalk drainage system to prevent ponding that can damage pavement and affect pedestrian safety. Kombespol Street is part of Lamongan City Center and functions as a strategic corridor for trade, offices, education, and public facilities. Initial observations identified pavement cracking, local settlement, uneven surfaces, side obstacles, and potential water ponding. These conditions indicate a gap between pedestrian mobility needs and the quality of the available infrastructure and support the need for an integrated evaluation of technical conditions, PLOS, and user perception [9].

This study therefore aims to (1) evaluate the technical condition of the pedestrian infrastructure, (2) determine the Pedestrian Level of Service (PLOS), and (3) assess user perceptions of sidewalk quality on Kombespol Street.

2. Methods

2.1. Research location and time

The research was conducted on Kombespol Street (Jalan Komisaris Besar Polisi Moh. Duryat), Lamongan Regency. The study corridor is approximately 1,100 m long and is located in a city-center area with commercial, office, educational, and public-facility functions. The location was selected because of its strategic role, relatively high pedestrian activity, and diverse surrounding land uses. The overall research period was January-May 2026, covering preparation, field data collection, data processing, analysis, and report preparation.

2.2. Sample and data collection

The questionnaire sample consisted of 50 sidewalk users selected using accidental sampling. The sample size followed the Lemeshow approach for an unknown population, using a 95% confidence level, an assumed proportion of 0.5, and a margin of error of 0.14, resulting in approximately 50 respondents. Primary data consisted of questionnaire responses, field observations of pavement, drainage, and supporting facilities, geometric measurements, and pedestrian counts. Secondary data included regional maps, land-use information, literature, and relevant technical standards [3].

2.3. Data analysis methods

PLOS was analyzed using the Highway Capacity Manual (HCM, 2000) framework [7]. First, pedestrian volume was obtained by counting all pedestrians within the selected observation segment during each

observation period. The PLOS observation segment was 25 m long, while the effective pedestrian width was 2 m, excluding areas occupied by side obstacles. Thus, the effective pedestrian area was calculated as:

$$A = L \times W = 25\ \text{m} \times 2\ \text{m} = 50\ \text{m}^2 \quad (1)$$

The pedestrian density was then calculated as:

$$D = \frac{V}{A} \quad (2)$$

followed by pedestrian space:

$$S = \frac{1}{D} \quad (3)$$

The observation period with the highest pedestrian count was treated as the peak observed period and was used for the PLOS calculation. The resulting space value was compared with the A-F LOS classification. Questionnaire responses were recorded using a five-point Likert scale and summarized using descriptive statistics in SPSS. The technical condition of the pedestrian infrastructure was analyzed descriptively by comparing field observations and measurements with the applicable technical criteria, while the final interpretation combined the technical findings, PLOS result, and user perceptions.

3. Results and Discussion

3.1. Pedestrian Level of Service (PLOS) analysis

Pedestrian counts were conducted on a holiday at the selected 25 m observation segment. The observation was divided into three periods, each lasting 30 minutes: morning (07:30-08:00), midday (12:00-12:30), and afternoon (16:00-16:30). The numbers of pedestrians recorded were 38, 5, and 8 people, respectively. The peak observed volume was therefore the morning count of 38 people. With an effective sidewalk area of 50 m², this peak count was used to calculate pedestrian density and space, as summarized in Table 1.

Table 1. PLOS Analysis Results

Parameter	Result
Peak observed pedestrian volume	38 people / 30 min
Observation segment length	25 m
Effective sidewalk width	2 m
Effective pedestrian area	50 m²
Pedestrian density	0.76 people/m²
Pedestrian space	1.32 m²/person
LOS category	E

The density of pedestrians was calculated as:

$$D = \frac{V}{A} = \frac{38}{50} = 0.76\ \text{people/m}^2 \quad (4)$$

The corresponding pedestrian space was:

$$S = \frac{1}{D} = \frac{1}{0.76} = 1.32\ \text{m}^2\text{/person} \quad (5)$$

According to the LOS classification used in this study, a pedestrian space of 0.75-1.4 m²/person corresponds to LOS E. This level indicates that pedestrian movement space is already limited and approaches saturation, particularly when side friction further reduces effective width. The result

provides the basis for prioritizing improvements to the usable walking space and control of obstacles along the sidewalk.

3.2. User perception analysis

User perception analysis was conducted using SPSS for 50 respondents. The descriptive results show that the indicators were generally rated in the fair and poor categories. Table 2 presents the mean and standard deviation for 25 questionnaire items covering pavement, drainage, movement space, comfort, cleanliness, shade, accessibility, connectivity, and overall service.

Table 2. Descriptive Statistics of User Perception

No	Research Variable	Mean	Std. Deviation	Category
1	Sidewalk surface is flat and not bumpy	2.85	0.71	Fair
2	No cracks or subsidence on the pavement	2.87	0.69	Fair
3	Sidewalk width is enough for two people	2.59	0.83	Poor
4	Sidewalk slope is comfortable for walking	2.70	0.74	Fair
5	Pavement material is not slippery when raining	2.69	0.77	Fair
6	No water puddles on the sidewalk when raining	2.31	0.91	Poor
7	Drainage channels function well	2.43	0.88	Poor
8	Rainwater flows smoothly from the surface	2.54	0.82	Poor
9	Sidewalk dries quickly after rain	2.48	0.79	Poor
10	No trash blocking the water channel	2.67	0.75	Fair
11	I can walk freely without obstacles	2.73	0.76	Fair
12	No vendors or parking disrupting walking space	2.35	0.90	Poor
13	The sidewalk is clean	2.79	0.72	Fair
14	Trees or shade available along the sidewalk	2.41	0.85	Poor
15	Walking atmosphere feels comfortable	2.68	0.73	Fair
16	Sidewalk is easy to use for the elderly	2.49	0.82	Poor
17	Sidewalk can be used by wheelchair users	2.37	0.89	Poor
18	Ramps available at certain points	2.44	0.86	Poor
19	Connected to surrounding public facilities	2.76	0.71	Fair
20	Transfer to pedestrian crossing is easy	2.64	0.75	Fair
21	Pedestrian density is within comfortable limits	2.58	0.80	Poor
22	I can easily overtake other pedestrians	2.61	0.78	Fair
23	I can walk at normal speed without hindrance	2.66	0.74	Fair
24	Two-way pedestrian movement is smooth	2.57	0.79	Poor
25	In general, this sidewalk provides good service	2.72	0.73	Fair

The highest mean score was 2.87 for the statement “No cracks or subsidence on the pavement,” which was categorized as fair. The lowest mean score was 2.31 for “No water puddles on the sidewalk when raining,” categorized as poor. Other low-rated aspects included drainage channel performance (2.43), sidewalk drying after rain (2.48), wheelchair usability (2.37), availability of ramps (2.44), shade availability (2.41), and interference from vendors or parking (2.35). These findings indicate that drainage, side obstacles, and accessibility are the most visible weaknesses from the users’ perspective.

The technical observations, PLOS calculation, and perception results point to the same main issues. Although the measured geometric width of the sidewalk ranges from approximately 2.20 to 2.40 m, the usable width is reduced by side friction such as parked vehicles and vendor activity. Physical defects, drainage limitations, and the absence or inadequacy of supporting accessibility facilities further reduce the quality of pedestrian service. The combined findings support improvement measures focused on pavement repair, drainage maintenance and improvement, control of sidewalk obstacles, and provision of accessible facilities.

4. Conclusion

Based on the three research objectives, the conclusions are as follows. Regarding the technical condition of pedestrian infrastructure, the geometric width of the sidewalks on Kombespol Street generally ranges from 2.20 to 2.40 m, but the effective walking space is reduced by side obstacles such as parked vehicles and street vendors. Field observations also identified surface cracks, local settlement, uneven pavement, and water ponding. The drainage system is not yet optimal because of blocked channels, limited drainage inlets at some points, and less-than-optimal surface slopes.

Regarding the Pedestrian Level of Service (PLOS), the observation used a 25 m segment with an effective width of 2 m, giving an effective area of 50 m². The highest observed pedestrian volume was 38 people in the morning period (07:30-08:00). The resulting density was 0.76 people/m² and pedestrian space was 1.32 m²/person. Based on the HCM-based classification used in this study, the pedestrian facility is categorized as LOS E, indicating limited movement space and conditions approaching saturation.

Regarding user perception and satisfaction, the descriptive analysis of 50 respondents indicates that the infrastructure was generally perceived in the fair to poor range. The most important concerns were water ponding, drainage performance, side obstacles, limited supporting facilities, and inadequate accessibility for people with disabilities. These results are consistent with the field observations and indicate that improvements are needed in physical condition, drainage, comfort, safety, and accessibility.

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