EVALUATING PEDESTRIAN SAFETY AND PAVEMENT CONDITIONS IN AN URBAN CONTEXT: A SURVEY-BASED STUDY IN DHAKA, BANGLADESH

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ABSTRACT

In rapidly growing and densely populated cities in developing countries, pedestrian safety and pavement conditions are some of the most important aspects of sustainable urban roadways. In this study, an attempt has been made to carry out a survey-based analysis of pedestrian safety and pavement conditions in several selected roads of Dhaka City, Bangladesh. For an enhanced understanding of pedestrian experiences in dense urban road transport, and to provide practical recommendations, this study will contribute with practical observations. The study used questionnaire surveys and observational assessments. The data were collected from a diverse group of pedestrians to identify major risk factors and defects in pavements. The major focus of the survey was to assess pedestrian perceptions of safety, comfort, etc, on the basis of field observation. For instance, pavement conditions, signage, usability, and maintenance consistency were the main selected parameters which are crucial in terms of urban roadway. Significant levels of pavement defects were evident from the survey data, such as uneven road surfaces, poor drainage, and frequent obstructions. Moreover, pedestrian perception of the roadway usability and conditions was concerning. For instance, it was found from the results that only 15% (on average) of participants demonstrated a strong perception of safety while walking on the roads. Detailed observations proved that the Technical to Kallyanpur had a notably higher number of pavement defects (30 potholes, 25 alligator cracking, and 9 longitudinal cracking). Thus, the Technical to Kallyanpur route faces more severe pavement deterioration compared to the Technical to Mirpur 1. Besides that, only 4.00% of respondents reported any ongoing maintenance works. Consequently, the study underscores the urgent need for integrated planning strategies that prioritize pedestrian needs in urban transport policies. The findings will provide evidence-based insights to create a pedestrian-friendly roadway in an urban context.

Keywords: *Pavement condition, pedestrian safety, urban transport*

1. INTRODUCTION

A detailed analysis of road incidents and factors such as driver behaviour, pedestrian actions, vehicles, infrastructure, and the environment is required for the assessment of pedestrian safety (Budzynski et al., 2019). Pedestrians are the most vulnerable road users because they have the least protection (Iasmin et al., 2016). For the enhancement of walkability, accessibility, and sustainability in urban roadway systems, developing high-quality pedestrian infrastructure is essential (Fonseca et al., 2022). Due to various factors such as rising population densities, vehicular congestion, and the overall roadway conditions, the challenges of urban transportation have become increasingly complex. Although roads are designed as built environments intended to promote the safety and security of pedestrians, they often fail to meet the core objective in practice (Stoker et al., 2015). Various authors from the literature stated that safety risks increase when pedestrians are often forced to walk on the road due to poorly maintained, narrow, or dirty sidewalks (Corazza et al., 2016). In the previous literature, the importance of high-quality walking surfaces to ensure safety and comfort for older pedestrians is also discussed (Heinonen and Eck, 2007; Dunbar et al., 2004; Zegeer et al., 2013). Pedestrian safety and comfort in Dhaka are significantly influenced by footpath surface condition and maintenance, poor pavement quality, and reduced pedestrian level of service (Bhuiya et al., 2018). Inadequate pedestrian infrastructure in the City contributes to high perceived safety risks among pedestrians, as evidenced by survey-based assessments of pedestrian behaviour and risk perception (Bhattacharjee et al., 2022). Recent research in Dhaka indicates that inadequate crosswalk infrastructure, including poorly located crosswalks, a lack of guardrails, and insufficient lighting, significantly influences pedestrian behaviour and safety risk, highlighting the need for better walking facility design (Sakib et al., 2024). Moreover, pavement evaluations of arterial roads in Dhaka reveal extensive surface distress, including cracking, potholes, and poor drainage, which degrade pavement condition ratings and compromise ride quality, underscoring the need for systematic pavement condition assessment in urban safety studies (Hasan et al., 2024). Generally, pedestrian infrastructure often remains poorly maintained, sidewalks are often encroached by vendors, and damaged by construction activities in urban roadways. Thus, a systematic field analysis is crucial, although the relationship between walkability and pedestrian needs has been extensively studied (Marquet and Miralles-Guasch, 2015; Negron-Poblete et al., 2014).

By evaluating factors such as roughness, skid resistance, strength, deflection, and surface deterioration, the assessment of pavement condition is essential for maintenance and budgeting (Qureshi et al., 2022). Although walkability checklists, surveys, and analyses are widely available in both grey and scientific literature (Galanis & Eliou, 2012; Kelly et al., 2011; Maghelal and Capp, 2011), in the urban context of Bangladesh, Dhaka city, for instance, this type of analysis is crucial. A multifactorial approach by combining observational data with a survey-based pedestrian perspective can provide an understanding of how infrastructure quality, traffic dynamics, and user behaviour intersect to influence safety outcomes. Unlike traditional road safety studies that focus primarily on vehicular crash data or engineering audits, this research integrates user-centric insights to ground infrastructure evaluation in lived experience. Irregular maintenance and poor sidewalk construction cause uneven surfaces and reduce comfort and safety for pedestrians (Di Mascio et al., 2020). Outside walking and biking are important sources of exercise for maintaining healthy children; however, this is becoming increasingly rare (Kweon et a, 2021). It might be due to the increasing concerns regarding the urban traffic systems. Factors that significantly affect pedestrians' sense of safety or comfort include the presence of a sidewalk, barriers and buffers between pedestrians and motor vehicles, lateral separation from motor vehicles, motor vehicle volume and composition, driveway frequency and access volume, among other factors, and effects of motor vehicle traffic speed (Landis et al., 2001). Sustainable mobility encourages transportation modes that minimize environmental impact and improve urban efficiency (Gallo & Marinelli, 2020).

Accordingly, this study underscores the critical necessity of systematic evaluation of pedestrian safety and pavement conditions for sustainable urban roadway mobility. Some authors stated that for measuring pedestrian safety along streets, no established approach exists, and to assess street facilities, some of the current safety evaluation methods can be used, as some studies have evaluated street

infrastructure and facilities for pedestrians by assessing different criteria, such as security, safety, convenience, etc. (Asadi-shekari et al., 2015). Focusing on major arterial roads in Dhaka, the research seeks to identify and analyze the underlying infrastructural, behavioural, and environmental determinants that influence pedestrian vulnerability.

2. METHODOLOGY

In the current study, a mixed-methods approach was adopted to evaluate pedestrian safety and pavement conditions. It combines both qualitative and quantitative data collection techniques to capture user behaviour and infrastructural realities, in addition to two primary survey methods: roadside observations and pedestrian interviews. Both survey and pavement condition data were collected from the selected road segments (Technical to Kallyanpur and from Technical to Mirpur 1) manually by field observation. These routes were selected as the study area for several reasons, such as a high level of pedestrian movement, varying traffic volumes in peak and off-peak times both weekend and weekdays, and distinct pavement conditions. Thus, these routes provide an adequate number of respondents in addition to effective road defect observation. Observational surveys focused on real-time pedestrian behaviours and interaction with vehicular flow. Structured interviews captured pedestrian perceptions regarding safety, comfort, and infrastructure usage.

2.1 Study Area

Details of the study locations and study dates are provided in Table 1. Equal importance was given to selecting the number of people surveyed. The length of the chosen routes was 1.0 km and 1.7 km for Technical to Kallyanpur and Technical to Mirpur 1, respectively. The volume of vehicles and pedestrians is very high, and the routes are among the busiest and most vital for the people who travel regularly. The characteristics of these roads vary considerably, as there are underpasses, foot over bridges, markets, temporary roadside businesses, etc. Consequently, these characteristics influence pedestrian behaviour and overall safety. Such variations make this corridor a representative sample for assessing pedestrian safety. The pedestrian and the pavement condition survey were carried out across the whole length of each segment. The locations are shown in Figure 1 and Figure 2.

Table 1: Study area and survey details

Road	Length	Date and Time	No of People Surveyed
Technical to Kallyanpur	1.7 km	23-08-2024 at 3.00 PM	75
Technical to Mirpur 1	1.1 km	23-08-2024 at 10.00 AM	75

Figure 1: Survey road: Technical to Kallyanpur

Figure 2: Survey road: Technical to Mirpur 1

2.2 Pedestrian survey and pavement condition data collection

For the assessment of pedestrian perception, a structured pedestrian survey form was prepared with a diverse category of questions. Demographic information is crucial to get the overall proportion of road users in terms of age and gender. The study tried to collect opinions from people of all ages. A total of 16 targeted questions were developed to gather data on perceptions, road uses, safety concerns, roadway infrastructures, and experiences. People's opinion on the current road condition on both structural and experience-based, is crucial. The pedestrians who participated in the survey were selected from various locations along the routes. A comprehensive understanding of the real-time issues faced by pedestrians is obtained from the responses, which are discussed later in the manuscript. In Figure 3, the survey form is provided. The major focus regarding the collection of the data was to include a diverse group of people, getting information about pedestrian experience and pavement defects. Besides that, the pavement condition data were collected through detailed on-site field inspections, where each road segment was visually examined for distress such as potholes, longitudinal and other surface deformation.

Pedestrian Survey Form

Road :
Length :
Date and Time :

Questions	Response Options
Demographic Information	
1. Age	☐ Under 18 ☐ 18-24 ☐ 25-34 ☐ 35-44 ☐ 45-54 ☐ 55-64 ☐ 65+
2. Gender	☐ Male ☐ Female
3. How often do you walk on the Road?	☐ Daily ☐ Weekly ☐ Monthly ☐ Rarely ☐ Never
Pavement Conditions	
4. How would you rate the overall condition of the pavement on the Road?	☐ Excellent ☐ Good ☐ Fair ☐ Poor ☐ Very Poor
5. Are there cracks or holes on the pavement?	☐ Yes ☐ No
6. If yes, how severe are the cracks or holes?	☐ Minor ☐ Moderate ☐ Severe
7. Is the pavement uneven or wobbly?	☐ Yes ☐ No
8. Are there areas where water accumulates on the road?	☐ Yes ☐ No
9. Are there any broken or damaged edges on the pavement?	☐ Yes ☐ No
10. Are there any loose or missing paving stones?	☐ Yes ☐ No
11. Is the pavement surface slippery, especially when wet?	☐ Yes ☐ No
12. Is the pavement well-lit at night?	☐ Yes ☐ No
13. Do you feel safe walking on this pavement?	☐ Very Safe ☐ Somewhat Safe ☐ Neutral ☐ Somewhat Unsafe ☐ Very Unsafe
14. How accessible is the pavement for people with disabilities?	☐ Very Accessible ☐ Somewhat Accessible ☐ Neutral ☐ Somewhat Inaccessible ☐ Very Inaccessible
15. Are there crosswalks or pedestrian signals at intersections?	☐ Yes ☐ No
16. Are there any repairs or maintenance currently being carried out on the pavement?	☐ Yes ☐ No

Figure 3: Pedestrian survey form used on both roads

3. RESULTS AND DISCUSSION

In evaluating the demographic parameter of the pedestrians, it was found that the age distribution was broad. The highest representation was found in the 35-44 (43) age group. In the case of gender distribution, the males (110) significantly outnumbered females (40). Most participants reported walking on the roads daily (60) or weekly (69). Thus, these route users are young and travel by those roads regularly. Among the people surveyed, a total of 100 respondents said that the pavement conditions as "Good," and a total of 36 rated them "Fair" or "Poor,". A large number of people (122) answered that there are cracks or holes in pavements. Additionally, 69 people described the defects as

moderate in severity. Damage was further evident, with 93 noting broken edges and 46 reporting missing paving stones. A concerning 73 reports found the pavement slippery when wet. Lighting conditions were relatively favourable, with 86 confirming adequate illumination. In terms of safety, only 32 felt "Very Safe," while most (94) felt "Somewhat Safe." Despite evident deterioration, only 6 respondents observed any ongoing repairs. Visual illustrations of all the findings are provided in Figure 4 and Figure 5. Notably, only 31 respondents felt safe when they walked on the roads. 73 number of respondents found the roads were slippery during wet. Approximately 81.33% of the pedestrians reported that there are cracks on the road surface.

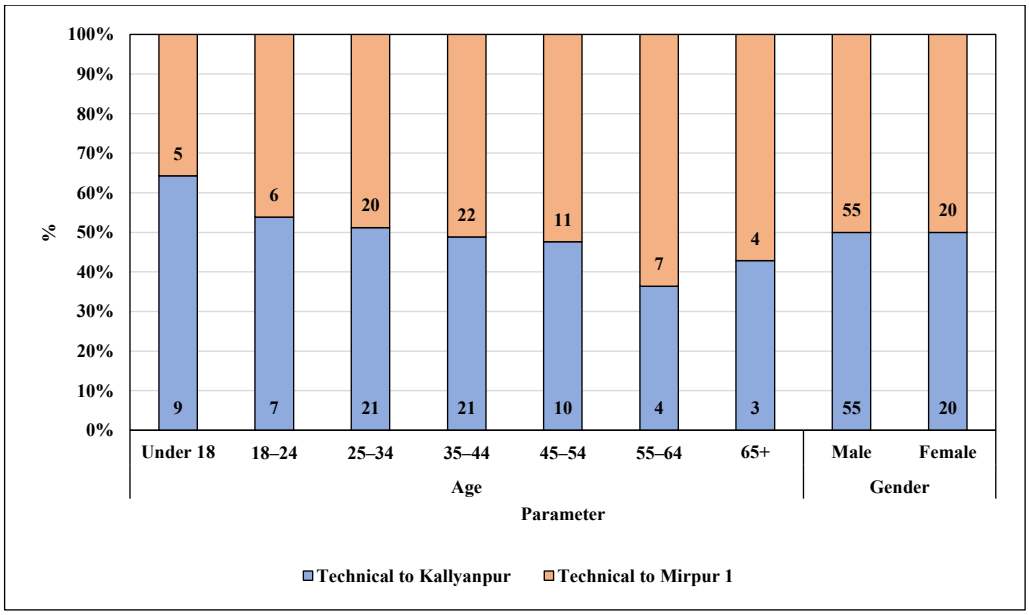


Figure 4: Survey results of the demographic indicators

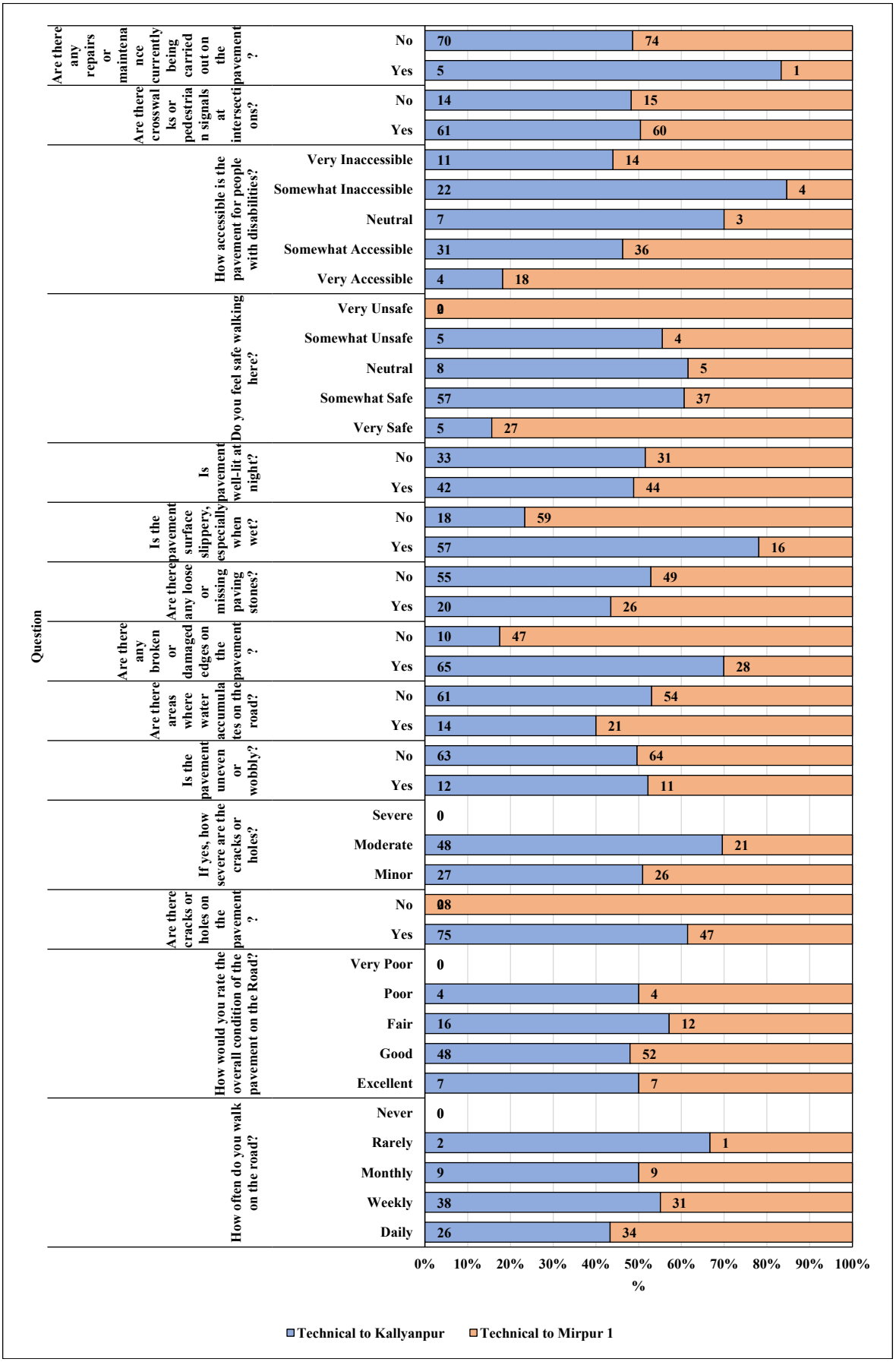


Figure 5: Comparative distribution of the pavement conditions

3.1 Comparative Pavement Condition Analysis

Table 2 below provides the comparative analysis of pedestrian responses obtained from the survey. Demographically, both areas feature a predominantly male pedestrian population (73.33%). Technical to Kallyanpur segment showed a slightly younger demographic condition as the route was dominated by the 25-34 and 35-44 age groups (28.00% both), compared to Technical to Mirpur 1, where 35-44-year-olds form the largest group (29.33%). In case of walking patterns, Technical to Mirpur 1 sees more daily walkers (45.33%) compared to Technical to Kallyanpur (34.67%). Additionally, Kallyanpur relies more on weekly usage (50.67%). Pavement conditions in Technical to Kallyanpur are significantly worse. 100.00% of the road showing cracks or holes, compared to 62.67% in Technical to Mirpur 1. Additionally, Technical to Kallyanpur faces higher levels of water accumulation (18.67%) and severe pavement damage. Accessibility for disabled pedestrians is also far better in Technical to Mirpur 1 (72.00%), compared to Technical to Kallyanpur (46.67%).

Table 2: Overview of the pavement quality and accessibility

Category	Indicator	Technical to Kallyanpur	Technical to Mirpur 1	Remarks
Demographics	Dominant Age Group	25-34, 35-44 (28.00%)	35-44 (29.33%)	Technical to Kallyanpur road users are slightly younger overall
	Gender	Male 73.33%, Female 26.67%	Male 73.33%, Female 26.67%	Gender distribution is identical
Walking Frequency	Daily walkers	34.67%	45.33%	Technical to Mirpur 1 has higher daily pedestrian activity
	Weekly walkers	50.67%	41.33%	Technical to Kallyanpur relies more on weekly usage
Pavement Condition	Good and Excellent	73.33%	78.67%	Both roads are perceived as mostly good, Mirpur slightly better
	Cracks/Holes Present	100%	62.67%	The Technical to Kallyanpur pavement is universally damaged
	Crack Severity (Moderate)	64.00%	44.68%	Technical to Kallyanpur cracks are more severe on average
	Uneven/Wobbly	16.00%	14.67%	Both roads are largely stable
	Water Accumulation	18.67%	28.00%	Technical to Mirpur 1 is more prone to puddling
	Broken/Damaged Edges	86.67%	37.33%	The edges of Technical to Kallyanpur are heavily damaged
	Loose/Missing Paving Stones	26.67%	34.67%	Slightly higher in Technical to Mirpur 1
	Slippery When Wet	76.00%	21.33%	The Technical to Kallyanpur route is significantly more hazardous in wet conditions
	Well-lit at Night	56.00%	58.67%	Lighting is adequate for both roads
Pedestrian Safety	Very/Somewhat Safe	82.67%	85.33%	Technical to Mirpur 1 pedestrians feel slightly safer
Accessibility for Disabled	Very/Somewhat Accessible	46.67%	72.00%	Technical to Mirpur 1 is significantly more accessible
Crosswalks/ Signals	Present	81.33%	80.00%	Both roads have reasonable intersection safety

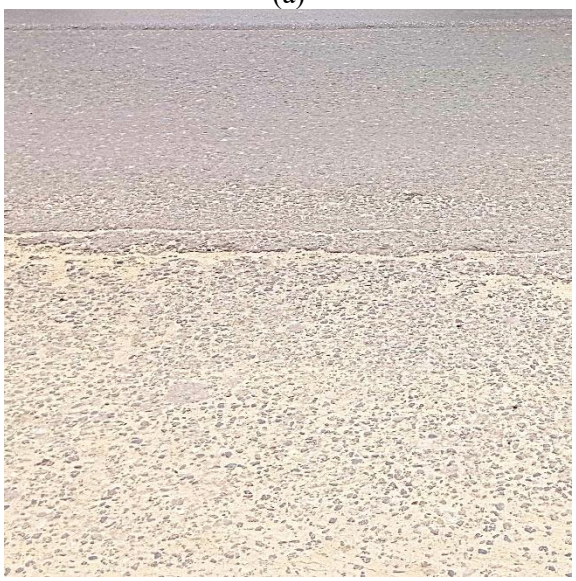
Maintenance	Repairs Ongoing	6.67%	1.33%	Technical to Kallyanpur is slightly more maintained, but overall, very low

3.2 Pavement defects

Four main types of pavement defects such as such as Alligator Cracking, Block Cracking, Longitudinal Cracking, and Potholes, were found from the road condition survey (Figure 6). Potholes were the most prevalent among the defect types. A combined total of 51 instances (30 in Technical to Kallyanpur and 21 in the Technical to Mirpur 1) were observed. Alligator Cracking followed closely. It was observed 44 times in total. Higher concentration was obtained in Technical to Kallyanpur (25) compared to Technical to Mirpur 1 (19). Block Cracking was reported 24 times, again, more frequently in Technical to Kallyanpur (14) than in Technical to Mirpur 1 (10). In every category, the Technical-Kallyanpur route showed a higher count of defects. These results align with respondents' survey feedback. Thus, the is an urgent need for targeted repair and maintenance efforts.

(a)

(b)



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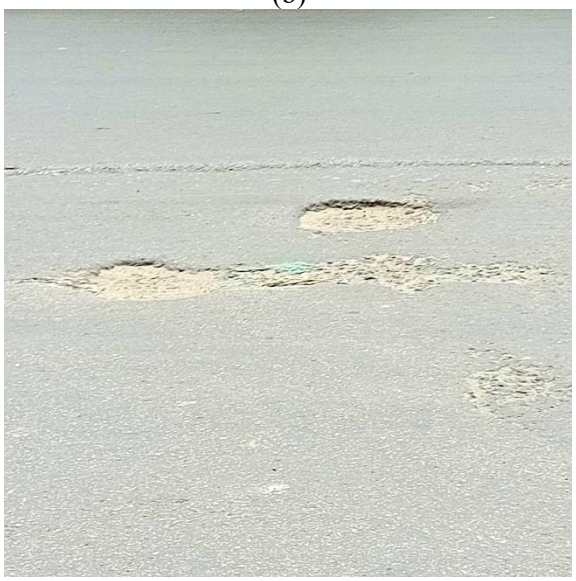

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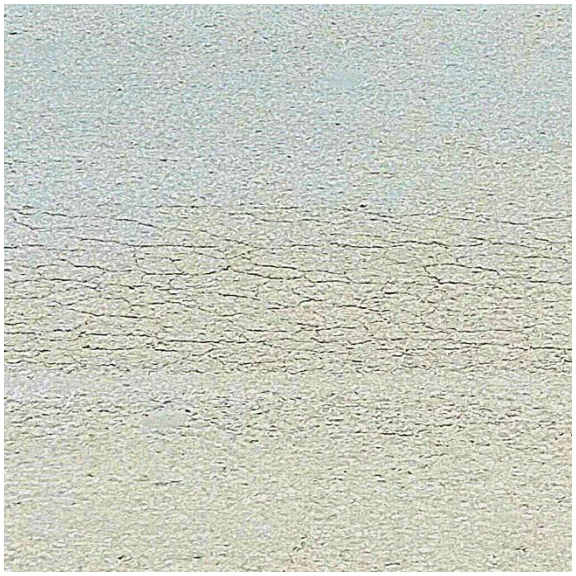

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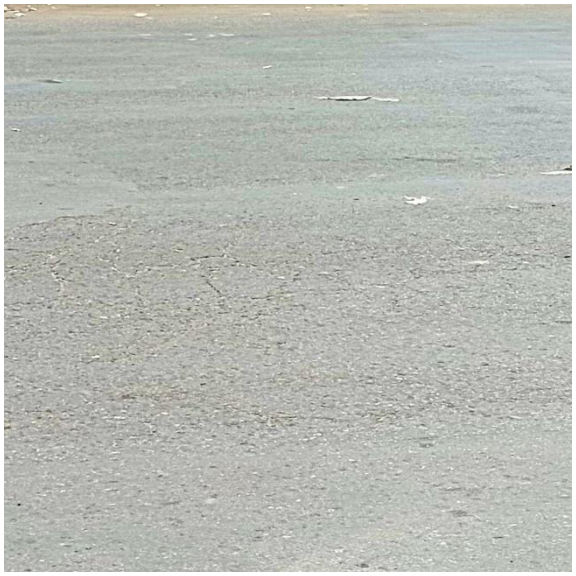

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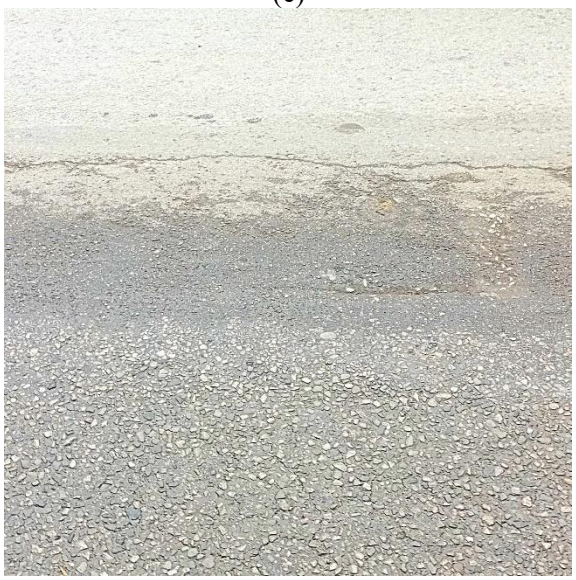

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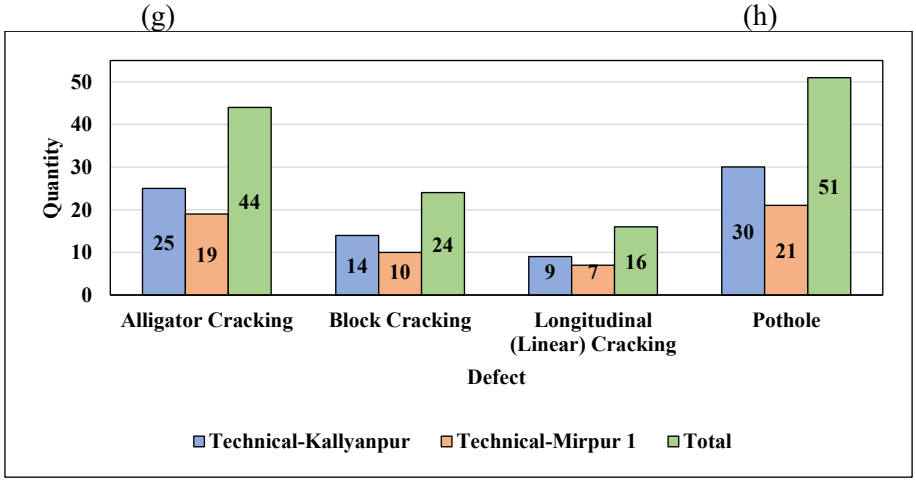

(i)

Figure 6: Pavement defects along Technical to Kalyanpur route: (a) Alligator Cracking, (b) Block Cracking, (c) Longitudinal (Linear) Cracking, and (d) Pothole, Pavement defects along Techical to Mirpur 1 route: (e) Alligator Cracking, (f) Block Cracking, (g) Longitudinal (Linear) Cracking, and (h) Pothole, and (i) Condition of pavement defects

4. CONCLUSIONS

The objectives are to evaluate the quality of pavements, identify major defects, and assess pedestrian safety and accessibility. A field observation-based method is necessary in this regard. This study aimed to address the pedestrian perceptions and pavement conditions in the urban context. For this reason, several routes were selected in Dhaka city. The collection of pavement defect data and surveying of people's perceptions, especially in the busy traffic conditions in a densely populated area, was challenging. Major findings are as follows: (1) A significant portion of respondents (81.33%) reported cracks or holes in the pavement. (2) 23.33% people noted water accumulation on the road. (3) Pavement defects were found in greater numbers in the Technical to Kallyanpur route. (4) Pedestrians expressed moderate to low safety perceptions (only 32 respondents felt "Very Safe."). (5) Access for disabled individuals was notably better in Technical to Mirpur 1. Though this study provides valuable insights into pedestrian infrastructure and safety from direct field data analysis, it has some limitations. The sample of population surveyed may not fully capture the nuances of pedestrian experience across all urban contexts, though adequate for an initial assessment. More roadways and a proper number of pedestrian surveys are necessary. However, this research is significant for planning and engineering applications. Municipalities can improve pedestrian safety for more sustainable and inclusive urban roadway environments by utilizing the current roadway conditions.

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DECLARATION OF USE OF AI

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