# CHAPTER 14

## Analyzing and Investigating Pedestrian Safety in Urban Environments

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**ABSTRACT**

Pedestrian safety is of extreme significance in the case of sustainable urban transport and mobility systems due to the direct effect it poses on the collective health and safety of individuals on the move in urban areas. In selecting a study area with dense pedestrian flow and mixed traffic conditions, the aim was to ensure an intensive analysis encompassing the range of pedestrian problems and traffic management issues. By adopting a structured approach through visual observations, checklist surveys, and gathering user views along specific road sections, the present study delves into the realm of pedestrian road safety. The survey uncovered a string of shared issues, from the inadequate maintenance of pathways and the absence of appropriate traffic-calming features to the inadequate provision of clear signage for pedestrians. Concluding the study, it not only identifies these key problems but also presents actionable solutions that can be a crucial guide for decision-makers, urban planners, and traffic authorities striving for overall road safety and giving paramount importance to pedestrian health within urban environments.

**Keywords:** Road safety; Road maintenance; Pedestrian safety; Pedestrian movement; Pedestrian crossing.

### 1.0 Introduction

India is the third largest road network in the world with rapid increase in the vehicles. The increase in the number of vehicles has increased the risk of accidents in the urban and rural areas. A road safety audit is a method of assessing the safety parameters of the road to provide safe and clear movement for the commuters. Road safety audit is a systematic approach for evaluation of safety parameters for new or existing roads to enhance the overall safety of the road.(Jain *et al.*, n.d.) This Road safety audit survey show the utilization of the safety protocol and pedestrians commutation problems.(Rahoof & Singh, 2017) The Road safety audit includes void range of strategies, polices and actions aimed at improving safety of pedestrians in urban environment for the reduction in pedestrians' safety in high volume traffic areas.(Factors Influencing Pedestrian Safety: A Literature Review by A Martin (TRL Limited) PPR241 Published project report, 2006).

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Road Accidents are increasing at a high rate all around the world day by day and one of the major cause for these accidents is ignoring the traffic rules.(Patel *et al.*, 2013) Conducting road safety audits and acting on the results can prevent or reduce the severity Road safety audits are appropriate for all types of road construction, including rehabilitation, upgrade, and new construction.(Galanis *et al.*, 2017)This study presents the analysis of the pedestrian traffic flow for each road segment for the selected road stretch. (Hnoohom *et al.*, 2024) Assessment of pedestrian safety based on the number of accidents is no longer sufficient. Accidents occur rarely and their number is expected to gradually decrease in the coming years, along with the improvement of road safety.(Olszewski *et al.*, 2016)Accidents for pedestrians occurs due to entering of motorized vehicles or while crossing roads are ranked high amongst the dangerous activities for pedestrians.(Gerogiannis & Bode, 2024)The Urban planners and government agency need innovative ideas and methods in improving both traffic operations and commuters safety. This data is helpful in providing solutions for the existing road conditions particularly in urbanized areas where the acquisition of additional land is limited. (Mohammed Almatar *et al.*, 2024)

## 2.0 Literature Review

The role of road safety audit (RSA0 in their identification and relief of safety hazards on road networks already built, especially in India, where most routes can't be easily changed. Studies show that checklists based on pre-set guidelines, such as IRC: SP: 88, are capable of systematically assessing road conditions, such as signs, markings, and pedestrian facilities. The study supports frequent monitoring and enhancement of road safety features to prevent accidents and increase user safety.(Patidar *et al.*, 2020)With respect to Russian road safety the number of studies and methods reflect the improvement for road safety according to European Union Directive 2008/96 guidelines.(Baklanova *et al.*, 2021) The need for road safety analysis (RSA) as a preventive intervention in road safety by identification and prevention of potential road safety issues. It also focuses on the increasing global concern about road safety (Kanuganti *et al.*, 2017) This study helps in concerted safety actions, combining education, enforcement, and engineering interventions to mitigate hazards and enhance pedestrian safety in different settings.(Pampapathi *et al.*, 2023) This study focuses on the various factors affecting pedestrian safety, with the observation that there are significant factors such as age, gender, socio-economic status, and environmental conditions that affect the behaviour of pedestrians. It is imperative to understand how pedestrian conduct relates to safety results, especially concerning crossing approaches and obedience to traffic rules.(Awsarmal *et al.*, 2020)

The document also recognizes the need to disseminate special needs for pedestrians, particularly vulnerable road users such as women, children, older citizens, and people with disabilities, in traffic management and road safety. It brings into context the high risk to which such groups are subjected under road transport systems and demands certain interventions to

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enhance their safety. Pedestrian security is a critical element of the overall road safety strategy of the report as a whole.(Report of the committee on road safety and traffic management, 2007) The report indicates that there are poor facilities to help pedestrians' cross highways safely, and hence a high rate of pedestrian deaths. It recommends that in the construction of highways, adequate provision for pedestrian crossings and safety features, such as central verges and railings, be made. Additionally, speed calming features need to be implemented along pedestrian-dense sections to enhance safety.(Koti *et al.*, 2012)

## 3.0 Problem Statement

The 7.4 km stretch from Radhachowk to University Circle in Pune city is one of the high-risk stretches for road users, with frequent accidents risk and severe pedestrian safety concerns. Despite ongoing efforts to enhance road safety, the area continues to witness high accident risk often resulting in serious injuries or fatalities. One of the major challenges is the lack of safe pedestrian infrastructure like narrow or missing sidewalks, inadequate pedestrian crossings, and the absence of proper traffic measures for the pedestrians. Pedestrians including students, daily commuters, and local residents often have to navigate fast-moving traffic without proper crossings, making their journey unsafe and unpredictable.

## 4.0 Objectives

- Identify High-Risk Pedestrian Areas
- Identify Obstructions on Pedestrian Pathways
- Assessing Pedestrian Infrastructure for Safer movement
- Evaluating the Effectiveness of Existing Road Safety Measures

## 5.0 Method and Materials

Road Safety Audit (RSA) is one of the basic and easy ways to assess the road safety parameters for traffic conditions and pedestrians' safety. The data collection for this study starts with the selection of location for the audit and then with data collection by visual imprints for the complete stretch. The checklist was prepared for the analysis and problem identification for pedestrians and collection of feedback from the road users is collected to understand the problem faced by commuting. The flow chart below provides the step-by-step approach for the road safety audit process.

### 5.1 Site selection

India is home for many new developing cities across its length and breadth; Pune is one of the fast-developing cities in the state of Maharashtra.

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**Figure 1: Flowchart of Research Methodology**

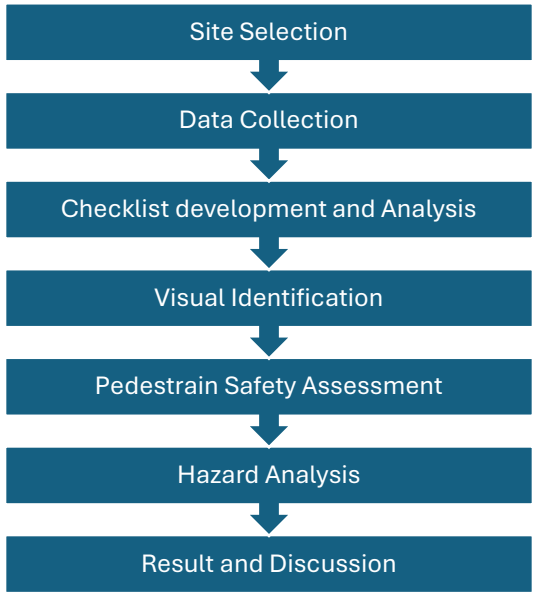
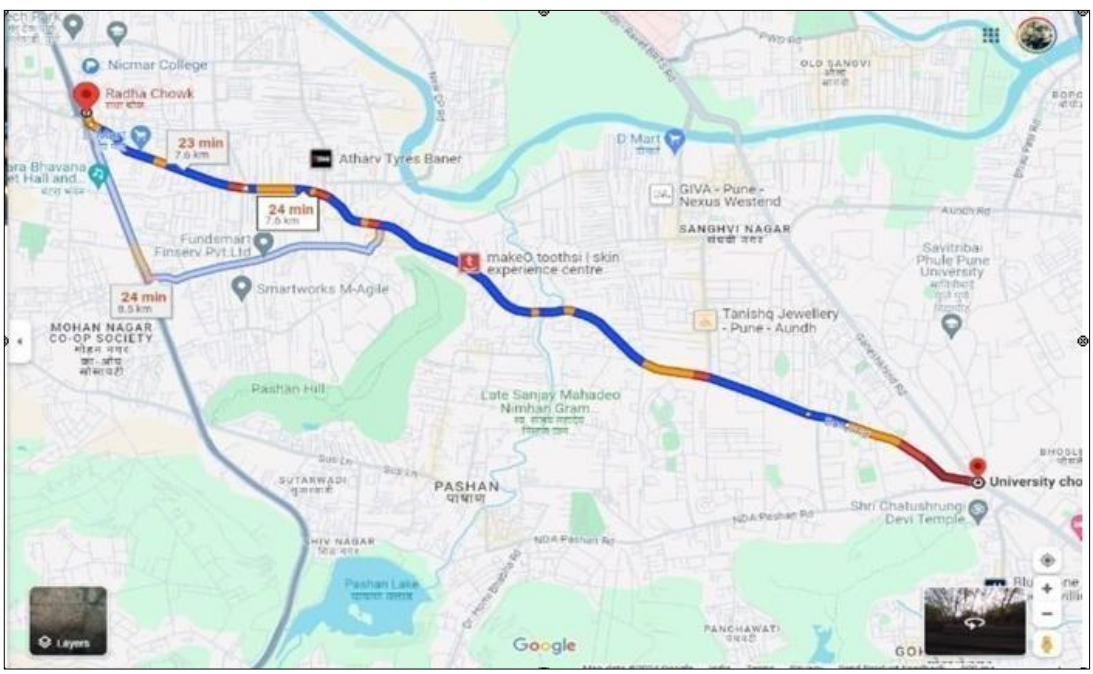



**Figure 2: Map of Selected Study Area**

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As the city is merging in traffic volume, the necessity of Road safety audit has increased in the recent years, and this case focuses on the Road safety audit for pedestrian safety was conducted. In this case a 7.40 km stretch from Radhachowk to University circle was selected for this study. The location was selected based on the high commuter traffic and more intersection. The case study focuses on pedestrian safety over this stretch for improving the accessibility for the users and to reduce the risk. The road safety audit is conducted as per the guidelines of IRC 83:2015 and Sundar committee recommendation.

**Figure 3: Checklist for the Pedestrians**

| SL.NO | ISSUE |
|---|---|
| | |
| 1 | Is width of the walkway comfortable for movement? |
| 2 | Is pedestrian's footpath paved or unpaved? |
| 3 | Presense of obstricles on walkway? |
| 4 | Is the adequate amount of street lighting facility provided? |
| 5 | Is there any encroachment along the walkway? |
| 6 | Are the adequate signage's provided for the pedestrians (stop, slowdown, work in progress)? |
| 7 | Are the ramps or slopes provide for wheelchairs provided? |
| 8 | Is the footpath having tactile paving for visual impaired person? |
| 9 | Is the plantation provided for good aesthetic? |
| 10 | Are the bollards provided at important locations? |
| 11 | Is the cyclist route provided? |
| 12 | Is there adequate separation between pedestrians and vehicles? |
| 13 | Is the footpath has any type kerb's stone? |
| 14 | Is visibility clear line of sight for walkers? |
| 15 | Are there resting areas provided for pedestrains? |
| | |
| 16 | Is the intersection has zebra cross? |
| 17 | Is the pedestrian movement easy at the intersection? |
| 18 | Visible pedestrian warning signs for drivers? |
| 19 | Are the ramps provided at intersection? |
| 20 | Stoppage Sign at Intersection? |
| | |
| 21 | Are handrails and guardrails are provided? |
| 22 | Is the pedestrian surface free of gravel and sand, and with good skid resistance? |
| 23 | CCTV survey lines is available? |
| 24 | Are barriers in place near high-risk zones? |
| 25 | Are there signs warning of potential hazards? |

The road safety audit is conducted using 3 prolonged strategies.

1. Checklist
2. Visual imprints
3. Commuters feedback.

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*Checklist:* The Checklist is prepared using IRC 103(Koti *et al.*, 2012) guidelines for this road safety audit for pedestrian's safety. This checklist is prepared based on the consideration and requirements that should be provided for the safety of the pedestrians. The checklist includes the walkway parameters like providing bollards, pavers, kerbs and zebra crossings for the pedestrians.

*Visual imprints:* Visual imprints were collected at every 100m distance to identify the condition of walkways, intersections, and signage's. The visual imprints provide the current condition of the pathways and what are the safety measures provided for the pedestrians for easy and comfortable movement across the road.

**Figure 4: Image of Road Conditions**

*Feedback collection:* The pedestrian's data was collected by questionnaire survey over the complete stretch of the study road. The study included various parameters related to the pedestrian walkway condition and utilization. The study shows asymmetric in views and more improvements across the complete stretch.

## 6.0 Results and Discussion

The data collected on the basis of the strategies for the road safety audit are categorized and are colour coded for easy identification and rectifying the complication faced by the pedestrians on the path. The colours are coded on the basis for availability on basic infrastructure like CCTV, proper maintenance, presence of paved walkways and encroachment.

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**Table 1: Color for Representation**

| |
|---|
| **Green**- Sufficient walkway |
| **Yellow** – walkway with minor correction without maintenance |
| **Orange** – improper maintenance with a breakdown |
| **Red** – major correction is required, and a new walkway is to be developed |

**Table 2: Color Coding Methodology**

| Sr. No. | Color | Issues | Images |
|---|---|---|---|
| 1 | Green | • CCTV is not provided at the intersection |  |
| 2 | Yellow | • Plantation is not present at some stretch<br>• Lighting is not installed at some stretch<br>• Required cycle path<br>• Traffic sign boards are missing<br>• No proper ramp is provided at the intersection<br>• Tactile tiles are missing<br>• Kerb stone is missing |  |
| 3 | Orange | • Signals are not provided at the intersection<br>• People have Encroachment the Pedestrian<br>• No zebra crossing at the intersection<br>• Requires Replacement of bollards |  |

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| | | | |
|---|---|---|---|
| 4 | Red | • No parking space for vehicles<br>• The pedestrian walkway is not suitable for comfortable movement<br>• No pedestrian walkway at some stretch<br>• Pedestrian walkway repair |  |

**Figure 5: Color Coded Map along Stretch**


**Table 3: Risk Matrix for Pedestrian Safety Issues**

| Likelihood\ Severity | Low | Medium | High |
|---|---|---|---|
| Low | Tactile tiles missing | Traffic signals at intersections | Missing traffic signboards |
| Medium | No proper ramp at intersections | No parking space for vehicles | Kerb stone missing |
| High | Bollards missing | Walkway not comfortable<br>Pedestrian walkway repair<br>Encroachment on the pedestrian walkway. | No pedestrian walkway at some stretches<br>No zebra crossing at intersections |

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### 6.1 Hazard analysis

The study shows the identification and analysis of occurrence of hazard along the stretch. Analysis provides the reason for the issues identified for the commuters and end users.

**Table 4: Analysis of Hazard Occurrence**

| Sr. No. | Issue | Likelihood of Occurrence | Severity Level | Reasoning | Remarks / Action Plan |
|---|---|---|---|---|---|
| 1 | Pedestrian walkway repair | High | High | Unmaintained walkways can directly lead to slips, trips, and falls. | Immediate repair to prevent trips & falls. |
| 2 | People have encroached on the pedestrian walkway | High | High | Forces pedestrians onto the road, increasing the risk of accidents with vehicles. | Strict enforcement & clearance required. |
| 3 | No pedestrian walkway at some stretch | High | High | Pedestrians have no safe area to walk, leading to conflicts with vehicular traffic. | Construct proper walkways to prevent pedestrian-vehicle conflicts. |
| 4 | The walkway is not suitable for comfortable movement | Medium | Medium | May result in detours, minor injuries, or discomfort for users. | Upgrade and maintain walkway surface. |
| 5 | No parking space for vehicles | Medium | Medium | This leads to illegal parking, narrowing roads, and causing congestion that may result in accidents. | Implement designated parking zones. |
| 6 | Requires replacement of bollards | Medium | Medium | Missing or damaged bollards reduce segregation, exposing pedestrians to vehicular threats. | Replace bollards to separate pedestrian and vehicular traffic. |
| 7 | Tactile tiles are missing | Low | Low | Primarily affects visually impaired individuals, with less frequent incidents. | Install tactile tiles to improve accessibility for visually impaired pedestrians. |
| 8 | Kerb stone is missing | Medium | Medium | Increases the risk of vehicles mounting the pedestrian path. | Replace kerb stones to prevent vehicle intrusion. |
| 9 | No zebra crossing at the intersection | High | High | Pedestrians crossing roads without designated zones are highly vulnerable to accidents. | Install marked zebra crossings for pedestrian safety. |
| 10 | No proper ramp is provided at the intersection | Medium | Medium | Affects accessibility for wheelchairs, and strollers, but less direct risk of accidents. | Construct ramps for wheelchair and stroller access. |
| 11 | Signals are provided at the intersection | Low | Low | Proper signals reduce risks if followed. | Ensure proper maintenance of traffic signals. |
| 12 | Traffic signboards are missing | Medium | High | Miscommunication or lack of awareness for drivers may lead to accidents. | Install appropriate road safety signs. |
| 13 | Required cycle path | Medium | Medium | Lack of cycling paths can result in conflicts between cyclists and pedestrians or vehicles. | Create separate cycle lanes to avoid conflicts. |

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## 7.0 Findings of the Study

The study identifies several critical road safety issues along the 7.4 km stretch from Radha Chowk to University Circle in Pune, highlighting risks for pedestrians, cyclists, and motorists. The findings reveal three major concerns:

- *Pedestrian safety deficiencies:* Lack of proper walkways, encroachments, missing zebra crossings, and inadequate pedestrian infrastructure significantly increase the risk of pedestrian-vehicle conflicts.
- *Traffic management issues:* Missing signboards, improper parking spaces, and absence of dedicated cycle paths lead to congestion and unsafe road conditions.
- *Infrastructure and accessibility gaps:* The absence of ramps, damaged kerb stones, and missing tactile tiles impact accessibility for differently abled pedestrians and the elderly.

## 8.0 Recommendations

- Pedestrian safety improvements
  - Construct or repair walkways to ensure continuous pedestrian pathways with well-maintained surfaces, reducing the risk of falls.
  - Eliminate encroachments through strict enforcement policies to remove unauthorized vendors and structures obstructing pedestrian movement.
  - Install proper zebra crossings and ramps at intersections to enhance accessibility for wheelchair users and strollers.
  - Improve lighting and CCTV surveillance in poorly lit areas and key intersections for better security and traffic monitoring.
- Traffic management and road infrastructure
  - Provide designated parking areas to prevent illegal parking and road congestion.
  - Replace or install bollards to ensure pedestrian safety by restricting vehicle intrusion into walkways.
  - Develop dedicated cycle lanes to reduce conflicts between cyclists, pedestrians, and vehicles.
  - Install missing traffic signboards and road markings at intersections and key locations to provide clear guidance for pedestrians and drivers.
- Road safety audit and monitoring
  - Implement a periodic road safety audit to identify and rectify hazards proactively.
  - Enhance awareness and enforcement through public awareness campaigns, educating pedestrians and drivers on traffic safety and compliance.
  - Utilize technology such as AI-based video surveillance to monitor pedestrian movement, traffic flow, and accident-prone zones for data-driven decision-making.

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## 9.0 Conclusion

The study highlights the specific areas for more improvement and to improve the maintenance of existing infrastructure. This study reinforces the urgent need for pedestrian-friendly infrastructure to reduce accident rates and improve walkability. By implementing effective safety interventions and regulatory measures, urban roads can become safer for all users. By following this methodology, communities can systematically assess the safety of their streets and sidewalks for pedestrians. This information can then be used to develop plans to make improvements and create safer walking environments for everyone

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