

# **SCHOOL ZONE SAFETY**

## **A THESIS REPORT**

*Submitted in the partial fulfilment of the requirements for  
the award of the degree of*

## **Bachelor of Planning**

*By*

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**May, 2026**

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### DECLARATION

I **SANJANA SHAKYA**, Scholar No **2211002113** hereby declare that the thesis titled School Zone Safety submitted by me in partial fulfilment for the award of degree of Bachelor of Planning, at Maulana Azad National Institute of Technology, Bhopal, India, is a record of Bonafide work carried out by me. The matter/result embodied in this thesis has not been submitted to any other University or Institute for the award of any degree or diploma.

*Sanjana*

Signature of the Student

Date: 07/05/2026

### CERTIFICATE

This is to certify that the declaration made by **SANJANA SHAKYA** is true to the best of my knowledge and that the student has worked under my guidance for one semester in preparing this thesis.

RECOMMENDED

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(Dr. Rahul Tiwari)

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Place: Bhopal

## ACKNOWLEDGEMENT

I am deeply grateful to all those who supported and guided me through the course of this thesis — a work that has been as much a journey of learning as it is a document of research.

First and foremost, I express my sincere and heartfelt gratitude to my Thesis Guide, Dr. Rahul Tiwari, Professor, Department of Architecture and Planning, Maulana Azad National Institute of Technology, Bhopal. His scholarly guidance, constructive criticism, and patient mentorship at every stage of this study — from the initial framing of the research problem to the final proposals — have been invaluable. His insistence on rigour, precision, and grounding every recommendation in normative evidence has shaped not only this thesis but my understanding of planning practice.

I am sincerely thankful to the Thesis Coordinator, Dr. Preeti Onkar, Professor, Department of Architecture and Planning, MANIT Bhopal, for her diligent coordination of the Planning Thesis programme and for her academic guidance and constructive feedback throughout the review process. Her attention to detail and commitment to the quality of student work has been a constant source of motivation.

I extend my deep gratitude to Dr. Nakul Dhagat, Professor and Head of the Department of Architecture and Planning, MANIT Bhopal, for providing an inspiring academic environment within the department and for his encouragement toward meaningful and socially relevant research. His leadership and vision for the department have created the conditions that make work of this nature possible.

I am grateful to the faculty members of the Department of Architecture and Planning, MANIT Bhopal, for their teaching and guidance throughout my academic programme, which provided the conceptual foundation upon which this thesis has been built.

I thank the school authorities, teachers, and students of the five educational institutions in the Shivaji Nagar cluster, Bhopal, who generously gave their time to participate in perception surveys and field visits. Their willingness to share their experiences and

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concerns about the safety of children in school zones was the empirical heart of this research.

I am grateful to my colleagues and batchmates in the Department of Architecture and Planning for their camaraderie, intellectual exchange, and encouragement during the course of this work. Collaborative discussions with peers have enriched my thinking at several important junctures.

Finally, I owe a profound debt of gratitude to my family for their unconditional support, patience, and encouragement throughout my academic journey. Without their faith in me, this work would not have been possible.

This thesis is, above all, dedicated to the children of Shivaji Nagar and every school-going child in India who deserves a safe path to and from school.

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May, 2026

## सार

भारत में प्रतिवर्ष सड़क दुर्घटनाओं में विश्व की लगभग 11 प्रतिशत मौतें होती हैं, जबकि देश के पास विश्व के केवल 1 प्रतिशत वाहन हैं। देश में सड़क दुर्घटनाओं में होने वाली कुल मौतों में से लगभग 10 प्रतिशत बच्चे होते हैं, जिनमें से अनेक घटनाएँ विद्यालयों के समीप घटती हैं। नियोजित हस्तक्षेप के अभाव में भारतीय शहरों के स्कूल जोन तेज गति के वाहनों, अनुपस्थित या अतिक्रमणग्रस्त पैदल मार्गों, अव्यवस्थित पिक-अप एवं ड्रॉप-ऑफ स्थितियों तथा कमजोर प्रवर्तन से ग्रस्त हैं।

प्रस्तुत शोध प्रबंध भोपाल के शिवाजी नगर संस्थागत क्लस्टर में स्थित पाँच विद्यालयों के स्कूल जोन सुरक्षा का अध्ययन करता है। इसका उद्देश्य भारतीय सड़क कांग्रेस (IRC) के प्रकाशन IRC:SP:32-2023 के मानकों के अनुरूप एक समान, सुरक्षित, पूर्वानुमेय एवं बाल-हितैषी स्कूल जोन वातावरण स्थापित करना है।

अध्ययन की चार उद्देश्यात्मक संरचना इस प्रकार है: (i) 20–30 किमी/घंटा की IRC-निर्धारित गति सीमाओं, उठे हुए पैदल पार-पथों, रम्बल स्ट्रिप्स एवं कर्ब एक्सटेंशन के माध्यम से गति प्रबंधन एवं यातायात शांति का क्रियान्वयन; (ii) निरंतर फुटपाथ, जेब्रा क्रॉसिंग, गार्ड रेल, कर्ब रैंप एवं साइकिल सुविधाओं सहित पैदल एवं गैर-मोटर चालित गतिशीलता अवसंरचना को सुदृढ़ करना; (iii) संकेत-पट्ट, पेवमेंट चिह्नान्कन, CCTV निगरानी, यातायात विनियमन आदेश एवं यातायात पुलिस तैनाती के माध्यम से स्कूल जोन सीमांकन एवं प्रवर्तन तंत्र का मानकीकरण; तथा (iv) हरित बफर, जलवायु-लचीली डिजाइन, सड़क सुरक्षा पाठ्यक्रम एवं सामुदायिक भागीदारी के माध्यम से समावेशी, टिकाऊ एवं शैक्षिक दृष्टिकोण को प्रोत्साहित करना।

शोध पद्धति में प्राथमिक एवं द्वितीयक दोनों प्रकार के डेटा का एकीकरण किया गया है। प्राथमिक डेटा संग्रह में क्षेत्र निरीक्षण, IRC-अनुपालन मापदंडों पर आधारित संरचित अवसंरचना ऑडिट, स्पोट स्पीड सर्वेक्षण, GIS-आधारित संघर्ष बिंदुओं का स्थानिक मानचित्रण तथा पाँचों विद्यालयों के 269 छात्रों एवं शिक्षकों पर किए गए धारणा सर्वेक्षण शामिल हैं। तीन केस अध्ययनों — बेंगलूरु के सेंट जोसेफ स्कूल में YCARS कार्यक्रम, नई दिल्ली की '250 मीटर्स ऑफ हैप्पीनेस' CROSSWALK पहल और न्यूयॉर्क सिटी के Safe Routes to School कार्यक्रम — का विश्लेषण कर हस्तांतरणीय शिक्षाएँ प्राप्त की गई हैं।

4E नियोजन रूपरेखा (अभियांत्रिकी, प्रवर्तन, शिक्षा एवं प्रोत्साहन) के माध्यम से किए गए विश्लेषण में सभी आयामों पर प्रणालीगत कमियाँ उजागर हुईं। सर्वेक्षण में शामिल 269 हितधारकों में से 96.6 प्रतिशत ने सुरक्षा सुधार की आवश्यकता से सहमति व्यक्त की; 34.6 प्रतिशत ने अपने विद्यालयों के निकट सड़क दुर्घटनाओं का प्रत्यक्ष अनुभव किया था।

प्रस्तावित हस्तक्षेप में नौ उठे हुए पैदल क्रॉसिंग, 2,100 मीटर निरंतर फुटपाथ, 22 जेब्रा क्रॉसिंग, 44 कर्ब रैंप, पाँच पिक-अप/ड्रॉप-ऑफ बे, चार गेटवे ट्रीटमेंट, बारह स्पीड हम्प तथा 18 कैमरों का CCTV नेटवर्क सम्मिलित हैं। तीन-चरणीय कार्यान्वयन योजना के अंतर्गत Phase 1 में रु. 8–12 लाख, Phase 2 में रु. 130–155 लाख तथा Phase 3 में रु. 60–80 लाख की अनुमानित लागत से कुल रु. 2.0–2.5 करोड़ का निवेश प्रस्तावित है, जो BMC पूँजी बजट, AMRUT 2.0, Smart Cities Mission एवं मध्यप्रदेश राज्य सड़क सुरक्षा निधि से वित्त पोषित किया जा सकता है।

शोध प्रबंध यह निष्कर्ष प्रस्तुत करता है कि स्कूल जोन सुरक्षा केवल एक अवसंरचनात्मक चुनौती नहीं, बल्कि एक बहुआयामी नियोजन विषय है जिसमें अभियांत्रिकी, प्रवर्तन, शिक्षा एवं प्रोत्साहन के समन्वित प्रयास अपेक्षित हैं। यहाँ विकसित रूपरेखा भोपाल एवं अन्य भारतीय शहरों के समान संस्थागत क्लस्टर के लिए अनुकरणीय मॉडल के रूप में प्रस्तुत है।

मुख्य शब्द: स्कूल जोन सुरक्षा, बाल पैदल यात्री सुरक्षा, यातायात शांति, *IRC:SP:32-2023*, नगर नियोजन, भोपाल, 4E रूपरेखा, गैर-मोटर चालित परिवहन, स्कूल प्रॉक्सिमल जोन, शिवाजी नगर

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### ABSTRACT

India accounts for approximately 11 per cent of global road fatalities despite possessing only 1 per cent of the world's vehicles. Nearly 10 per cent of all road traffic deaths in the country involve children, with a significant proportion occurring in the vicinity of schools. In the absence of systematic planning interventions, school zones across Indian cities remain characterized by high vehicular speeds, absent or encroached pedestrian footpaths, chaotic pick-up and drop-off conditions, and weak enforcement — conditions that place children at disproportionate risk during their daily commute.

This thesis examines school zone safety in the Shivaji Nagar institutional cluster, Bhopal, comprising five schools on sub-arterial and collector roads. The aim is to establish uniformly safe, predictable, and child-friendly school zone environments that reduce child fatalities and traffic risks, benchmarked against the Indian Roads Congress publication IRC:SP:32-2023 (Road Safety for Children).

The study follows a four-objective structure: (i) enforcement of speed management and traffic calming through IRC-prescribed limits of 20–30 km/h, raised crosswalks, rumble strips, and kerb extensions; (ii) strengthening of pedestrian and non-motorized mobility infrastructure including continuous footpaths, zebra crossings, guard rails, kerb ramps, and dedicated cycling facilities; (iii) standardization of school zone delineation and integration of enforcement mechanisms through signage, pavement markings, CCTV surveillance, Traffic Regulation Orders, and traffic police deployment; and (iv) fostering inclusive, sustainable, and educational approaches through green buffers, climate-resilient design, road safety curriculum, and community participation.

The methodology integrates primary and secondary data. Primary data was collected through field observations and structured infrastructure audits assessed against IRC compliance parameters, spot speed surveys, GIS-based spatial mapping of conflict points, and stakeholder perception surveys administered to 269 respondents comprising students and teachers across the five schools. Secondary data comprised national policy documents, IRC technical standards, and published case studies. Three case studies — the YCARS programme at St. Joseph's School, Bengaluru; the 250 Metres of Happiness CROSSWALK initiative in New Delhi; and the Safe Routes to School programme in New York City — were analysed to extract transferable lessons for the study area.

The analysis, structured through the 4E Planning Framework (Engineering, Enforcement, Education, and Encouragement), revealed systemic deficiencies across all dimensions. All five schools lacked IRC-compliant speed limit signage, school zone markings, and raised pedestrian crossings. Footpaths were absent, discontinuous, or encroached in the majority of the 300-metre school proximal zone. No pick-up and drop-off bays existed at any school gate. Traffic police were absent during peak school hours, and CCTV coverage was nil. A

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survey of 269 stakeholders found that 96.6 per cent agreed or strongly agreed that safety improvements were urgently needed; 34.6 per cent had directly witnessed or experienced road accidents near their schools.

In response, the planning proposals present a comprehensive, phased intervention programme for the Shivaji Nagar Safe School Precinct. Physical interventions include nine raised pedestrian crossings, 2,100 metres of continuous footpath, 22 zebra crossings, 44 kerb ramps, five pick-up/drop-off bays, four gateway treatments, twelve speed humps, and an 18-camera CCTV network. Institutional and governance interventions include a School Zone Safety Committee, Traffic Regulation Orders under the Motor Vehicles Act 2019, a Safety Warden programme, and Road Safety Clubs in each school. A three-phase implementation plan delivers critical improvements within three months at Rs. 8–12 Lakh (Phase 1), the full engineering programme within twelve months at Rs. 130–155 Lakh (Phase 2), and long-term sustainability measures over two years at Rs. 60–80 Lakh (Phase 3), with a total indicative cost of Rs. 2.0–2.5 Crore fundable through BMC capital budget, AMRUT 2.0, Smart Cities Mission, and the Madhya Pradesh State Road Safety Fund.

The thesis concludes that school zone safety is not merely an infrastructural challenge but a multi-dimensional planning issue requiring coordinated action across engineering, enforcement, education, and encouragement. The framework developed here is designed to be replicable across similar institutional clusters in Bhopal and other Indian cities.

*Keywords: School Zone Safety, Child Pedestrian Safety, Traffic Calming, IRC:SP:32-2023, Urban Planning, Bhopal, 4E Framework, Non-Motorized Transport, School Proximal Zone, Shivaji Nagar*

## List of Abbreviations

| Abbreviation | Full Form                                              |
|--------------|--------------------------------------------------------|
| ADP          | Annual Development Plan                                |
| AM           | Ante Meridiem (morning)                                |
| AMRUT        | Atal Mission for Rejuvenation and Urban Transformation |
| ANPR         | Automatic Number Plate Recognition                     |
| ASTM         | American Society for Testing and Materials             |
| BBMP         | Bruhat Bengaluru Mahanagara Palike                     |
| BMC          | Bhopal Municipal Corporation                           |
| BSCL         | Bhopal Smart City Limited                              |
| CBSE         | Central Board of Secondary Education                   |
| CCTV         | Closed-Circuit Television                              |
| CEO          | Chief Executive Officer                                |
| CoRPS        | Concern for Road and Pedestrian Safety                 |
| CPR          | Cardiopulmonary Resuscitation                          |
| CSR          | Corporate Social Responsibility                        |
| DAV          | Dayanand Anglo-Vedic (school)                          |
| DDU          | Deen Dayal Upadhyay                                    |
| DEO          | District Education Officer                             |
| DLC          | Dry Lean Concrete                                      |
| DOT          | Department of Transportation                           |
| DSP          | Deputy Superintendent of Police                        |
| EV           | Electric Vehicle                                       |
| EVS          | Environmental Studies                                  |
| GIS          | Geographic Information System                          |

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|               |                                                              |
|---------------|--------------------------------------------------------------|
| <b>GNCTD</b>  | <b>Government of the National Capital Territory of Delhi</b> |
| <b>GBSSS</b>  | <b>Government Boys Senior Secondary School</b>               |
| <b>GGSSSS</b> | <b>Government Girls Senior Secondary School</b>              |
| <b>GVW</b>    | <b>Gross Vehicle Weight</b>                                  |
| <b>HSS</b>    | <b>Higher Secondary School</b>                               |
| <b>ICCC</b>   | <b>Integrated Command and Control Centre</b>                 |
| <b>ICPB</b>   | <b>Interlocking Concrete Paving Blocks</b>                   |
| <b>IIT</b>    | <b>Indian Institute of Technology</b>                        |
| <b>IRC</b>    | <b>Indian Roads Congress</b>                                 |
| <b>IRF</b>    | <b>International Road Federation</b>                         |
| <b>IS</b>     | <b>Indian Standard</b>                                       |
| <b>ITE</b>    | <b>Institute of Transportation Engineers</b>                 |
| <b>KPI</b>    | <b>Key Performance Indicator</b>                             |
| <b>KV</b>     | <b>Kendriya Vidyalaya</b>                                    |
| <b>LPI</b>    | <b>Leading Pedestrian Interval</b>                           |
| <b>MANIT</b>  | <b>Maulana Azad National Institute of Technology</b>         |
| <b>MIG</b>    | <b>Middle Income Group</b>                                   |
| <b>MP</b>     | <b>Madhya Pradesh</b>                                        |
| <b>MoRTH</b>  | <b>Ministry of Road Transport and Highways</b>               |
| <b>MoHUA</b>  | <b>Ministry of Housing and Urban Affairs</b>                 |
| <b>MUTCD</b>  | <b>Manual on Uniform Traffic Control Devices</b>             |
| <b>MV Act</b> | <b>Motor Vehicles (Amendment) Act, 2019</b>                  |
| <b>NACTO</b>  | <b>National Association of City Transportation Officials</b> |
| <b>NGO</b>    | <b>Non-Governmental Organisation</b>                         |
| <b>NHTSA</b>  | <b>National Highway Traffic Safety Administration</b>        |

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|                |                                                                               |
|----------------|-------------------------------------------------------------------------------|
| <b>NIMHANS</b> | <b>National Institute of Mental Health and Neuro Sciences</b>                 |
| <b>NMT</b>     | <b>Non-Motorised Transport</b>                                                |
| <b>NUTP</b>    | <b>National Urban Transport Policy</b>                                        |
| <b>NYCDOT</b>  | <b>New York City Department of Transportation</b>                             |
| <b>PM</b>      | <b>Post Meridiem (afternoon)</b>                                              |
| <b>PMC</b>     | <b>Pune Municipal Corporation</b>                                             |
| <b>PTA</b>     | <b>Parentā€Teacher Association</b>                                            |
| <b>PVC</b>     | <b>Polyvinyl Chloride</b>                                                     |
| <b>PWD</b>     | <b>Public Works Department</b>                                                |
| <b>RTO</b>     | <b>Regional Transport Officer</b>                                             |
| <b>RSC</b>     | <b>Road Safety Club</b>                                                       |
| <b>SAFETEA</b> | <b>Safe, Accountable, Flexible, Efficient Transportation Equity Act (USA)</b> |
| <b>SAZ</b>     | <b>School Access Zone</b>                                                     |
| <b>SP</b>      | <b>Superintendent of Police</b>                                               |
| <b>SPZ</b>     | <b>School Proximal Zone</b>                                                   |
| <b>SRTS</b>    | <b>Safe Routes to School</b>                                                  |
| <b>STZ</b>     | <b>School Transition Zone</b>                                                 |
| <b>SZSC</b>    | <b>School Zone Safety Committee</b>                                           |
| <b>TBM</b>     | <b>Transverse Bar Marking</b>                                                 |
| <b>TRO</b>     | <b>Traffic Regulation Order</b>                                               |
| <b>ULB</b>     | <b>Urban Local Body</b>                                                       |
| <b>URDPFI</b>  | <b>Urban and Regional Development Plans Formulation and Implementation</b>    |
| <b>UV</b>      | <b>Ultraviolet</b>                                                            |
| <b>VAHAN</b>   | <b>Vehicle Registration Database (Government of India)</b>                    |
| <b>WHO</b>     | <b>World Health Organization</b>                                              |

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|              |                                            |
|--------------|--------------------------------------------|
| <b>WMM</b>   | <b>Wet Mix Macadam</b>                     |
| <b>WRI</b>   | <b>World Resources Institute</b>           |
| <b>WSB</b>   | <b>Walking School Bus</b>                  |
| <b>YCARS</b> | <b>Young Change Agents for Road Safety</b> |

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## CHAPTER 1

### INTRODUCTION

#### 1.1 Background and Context

Children represent one of the most vulnerable segments of road users globally. The daily journey to and from school constitutes a period of heightened exposure to traffic-related risks for millions of children. In India, this vulnerability is compounded by rapidly urbanizing environments, heterogeneous traffic composition, and an inadequate pedestrian infrastructure network that has not kept pace with the country's explosive growth in motorization.

A 'School Zone' is defined as the designated area in the immediate vicinity of a school — typically within a radius of 300 meters from the school gate — where the presence of children creates a need for special traffic management and road safety measures. The regulation of speed, the provision of safe pedestrian crossings, appropriate signage, pick-up and drop-off facilities, and pavement markings together constitute the built environment of a safe school zone.

According to the Ministry of Road Transport and Highways (MoRTH), road traffic injuries claim over 1,50,000 lives annually in India — accounting for approximately 11 per cent of global road fatalities despite the country possessing only 1 per cent of the world's vehicles (MoRTH, 2023). Studies indicate that nearly 10 per cent of all road traffic fatalities in India involve children, and a significant proportion of these incidents occur in the proximity of schools. Children's inherent developmental limitations — including incomplete spatial cognition, inability to judge vehicular speed accurately, and tendency for impulsive behavior — render them disproportionately susceptible to road traffic injuries.

The Indian Roads Congress (IRC), through its publication IRC: SP:32-2023 (Road Safety for Children), provides comprehensive guidelines for the design and management of School Proximal Zones (SPZ), School Transition Zones, and School Access Zones. Complementary guidance is drawn from IRC:99-2018 (Guidelines for Traffic Calming Measures in Urban and Rural Areas) and IRC:103 (Guidelines for Pedestrian Facilities). Despite the existence of this normative framework, implementation on the ground remains

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inconsistent, uneven across states and city types, and largely driven by individual institutional initiatives rather than systemic planning mandates.

### 1.2 Problem Statement

School zones in Indian cities are characterized by a convergence of safety hazards: high-speed vehicular traffic in the absence of adequate warning signage, absence or encroachment of pedestrian footpaths, unregulated and chaotic pick-up and drop-off practices, insufficient or missing zebra crossings, and a general deficit of passive traffic calming infrastructure. These conditions are exacerbated during school arrival and dispersal hours — typically 7:00–9:00 AM and 2:00–5:00 PM — when pedestrian-vehicular conflict intensity peaks.

A diagnostic audit of schools in Bengaluru, published by NIMHANS, found that only 11.5 per cent of audited schools had speed limits displayed in the school vicinity, and merely 17 per cent of schools were situated on roads with school zone signage (Citizen Matters, 2019). This data, representative of conditions in one of India's most developed metropolitan areas, suggests the scale of deficiency that characterizes school zones across smaller cities and towns where institutional attention is even more limited.

The challenge, therefore, is not merely one of physical infrastructure provision. It encompasses questions about planning governance, inter-departmental coordination between traffic police, municipal bodies, school administrations, and parent communities; the enforcement of speed limits; and the integration of school zone safety planning within the broader urban mobility planning framework.

| Key Problem Indicators — School Zone Safety in India                                                              |
|-------------------------------------------------------------------------------------------------------------------|
| India accounts for ~11% of global road fatalities with only 1% of vehicles (MoRTH, 2023)                          |
| ~10% of road deaths in India involve children, many near school zones (IRF India Chapter, 2023)                   |
| Only 11.5% of Bengaluru schools have speed limits displayed near school gates (NIMHANS / Citizen Matters, 2019)   |
| Merely 17% of schools in Bengaluru are located on roads with school zone signage                                  |
| IRC: SP:32-2023 recommends a School Proximal Zone radius, but compliance remains largely voluntary and unenforced |

### 1.3 Significance of the Study

This thesis addresses the urgent need to examine school zone safety from a planning perspective — specifically through the lens of spatial analysis, policy evaluation, and design intervention. Unlike studies that focus solely on accident statistics or behavioral change, this research seeks to evaluate the environment built around schools against normative IRC guidelines, identify systemic gaps, and propose planning-level recommendations.

The significance of this work lies in its potential contribution to three domains:

- **Pedagogic Contribution:** The research adds to the growing body of Indian literature on child pedestrian safety, an area that has historically been under-studied relative to highway safety or mass transit planning.
- **Policy Contribution:** The findings will be synthesized into actionable recommendations directed at municipal planning authorities, traffic engineering departments, and school administrations, grounded in IRC standards.
- **Practice Contribution:** The case study-based approach, combining Indian and international examples, provides a comparative framework that can be adapted for school zone safety audits and improvement plans in similar urban contexts.

### 1.4 Aim and Objectives

#### 1.4.1 Aim

To establish **uniformly safe, predictable, and child-friendly school zone environments** that reduce child fatalities and traffic risks.

#### 1.4.2 Objectives

- **To enforce uniform speed management and traffic calming** by implementing IRC-mandated limits of 20–30 km/h in school zones and introducing raised crosswalks, rumble strips, and curb extensions to ensure controlled vehicular movement.
- **To strengthen pedestrian and non-motorized mobility infrastructure** through provision of sidewalks, zebra crossings, guard rails, curb ramps, and medians, while promoting walking and cycling via safe pathways, dedicated lanes, and child-friendly urban design.
- **To standardize school zone delineation and integrate enforcement mechanisms** by establishing clear boundaries, visible signage, and road markings

as per IRC SP:32, supported by traffic police deployment, CCTV monitoring, and community-based vigilance to reduce speeding and unsafe driving behaviors.

- **To foster inclusive, sustainable, and educational approaches** by reducing vehicular emissions through compact planning, green buffers, and climate-resilient infrastructure, while engaging children, parents, and teachers in safety education programs and promoting equitable access to transport and urban amenities.

## 1.5 Scope and Limitations of the Study

### 1.5.1 Scope

The scope of this study is confined to the assessment of school zone safety conditions within the defined School Proximal and Transition Zones of selected educational institutions in Shivaji Nagar, Bhopal. In line with national school zone planning practices, the spatial boundary extends approximately 300–500 meters from the main school gate. The study emphasizes the evaluation of physical infrastructure and traffic management elements that influence child pedestrian safety, including the availability and continuity of footpaths, pedestrian crossings, traffic calming measures, speed regulation, signage and road markings, visibility conditions, and pick-up and drop-off arrangements during school hours. The research methodology integrates primary data collection through field observations, infrastructure audits based on IRC-aligned parameters, perception surveys of students and school authorities, and spatial mapping of conflict points. Secondary data from national guidelines, published reports, and relevant case studies are also utilized to frame evaluation criteria and planning recommendations. The outcome of the study is limited to planning-level proposals and policy recommendations aimed at enhancing the safety of school-going children through engineering interventions and regulatory measures, thereby contributing to safer and more inclusive urban environments in Bhopal.

### 1.5.2 Limitations

The study is subject to certain limitations. Detailed school-specific accident data were not available for comprehensive statistical trend analysis, and therefore risk assessment is primarily based on infrastructure condition and observational indicators.

Field surveys were conducted within a limited time frame and during selected weekdays, which may not fully capture seasonal variations or atypical traffic patterns. Perception-based responses collected through questionnaires may involve subjective bias.

The study primarily emphasizes engineering and planning aspects of school zone safety. Behavioural education programmes, long-term enforcement effectiveness, and financial feasibility assessments are not examined in depth.

Finally, the findings are context-specific to Shivaji Nagar, Bhopal, and while the methodology may be replicable, the proposed interventions may require adaptation when applied to different urban settings.

### **1.6 Study Area Identification and Introduction**

The study area is located in Shivaji Nagar, Bhopal, a well-established residential and institutional neighborhood within the municipal limits of Bhopal city, Madhya Pradesh. Shivaji Nagar is characterized by a mix of residential colonies, local commercial activities, and educational institutions, resulting in moderate to high pedestrian and vehicular interaction throughout the day.

The selected study area comprises a cluster of five educational institutions situated within close proximity to one another. This spatial concentration of schools generates significant pedestrian movement during morning arrival and afternoon dispersal hours. Students access the schools through multiple modes including walking, bicycles, auto-rickshaws, two-wheelers, and private cars. The convergence of these modes within narrow carriageways and limited pedestrian infrastructure creates conflict points near school gates and adjacent intersections.

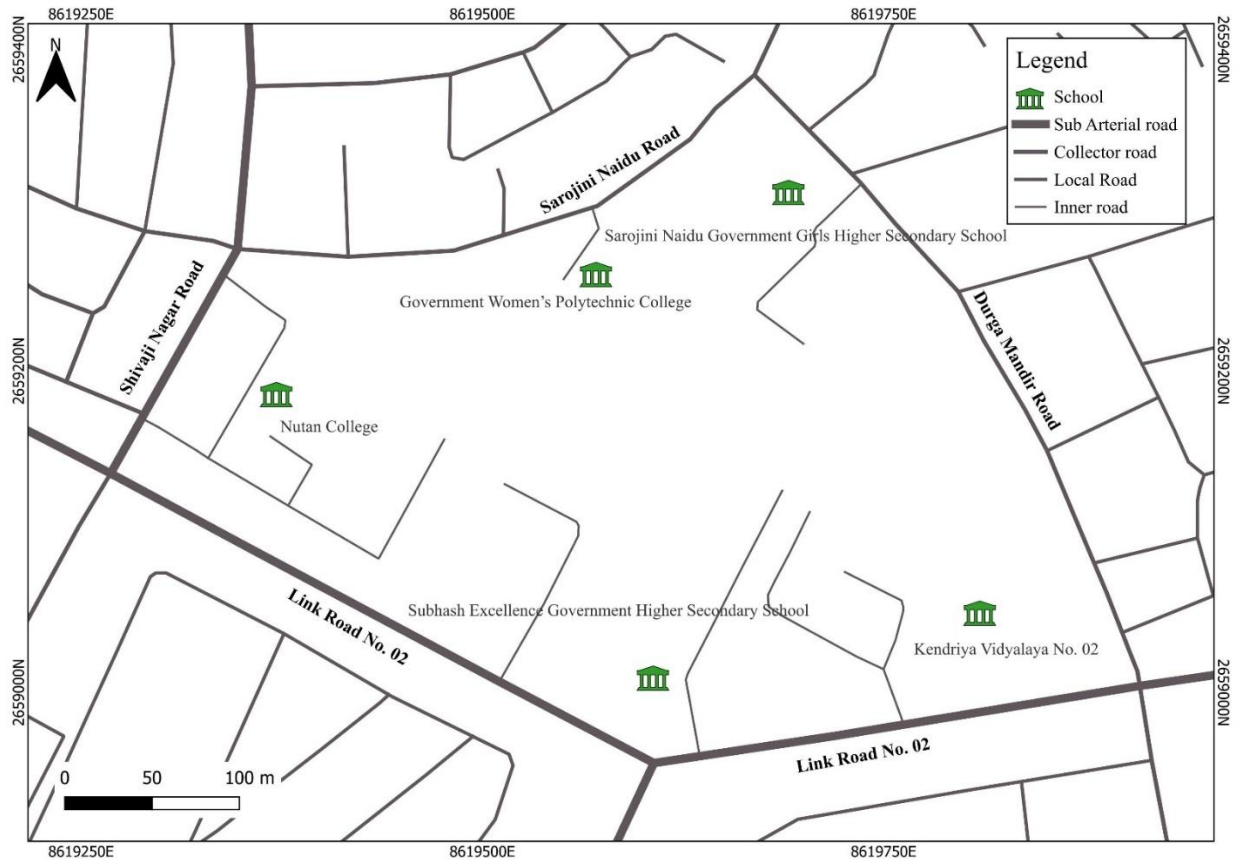
The surrounding road network consists primarily of collector and sub-arterial roads that cater not only to institutional traffic but also to traffic connecting adjoining residential and commercial areas. On-street parking, informal vending, and unregulated pick-up and drop-off activities further reduce effective carriageway width and obstruct pedestrian visibility. In several stretches, footpaths are either discontinuous, encroached, or absent, compelling students to walk on the carriageway.

The study area was selected due to its representative urban character, concentration of educational institutions, and observable safety concerns during school peak hours. These characteristics make Shivaji Nagar an appropriate case for evaluating school zone conditions against established safety standards and proposing structured planning interventions.





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### 1.7 Research Questions

- What are the existing conditions of school zones in the study area when assessed against IRC: SP:32-2023 parameters for the School Proximal Zone, School Transition Zone, and School Access Zone?
- What are the primary categories of safety deficiency — infrastructure, signage, traffic management, or governance — in the identified school zones?
- What lessons can be drawn from successful Indian and international school zone safety interventions to inform planning recommendations for the study area?
- What planning-level interventions are most feasible, impactful, and scalable in the context of the study area's institutional and resource constraints?

## CHAPTER 2

### LITERATURE REVIEW, POLICY FRAMEWORK & CASE STUDIES

#### 2.1 Introduction to the Literature Review

This chapter synthesizes the existing body of knowledge on school zone safety, drawn from national and international scholarship, planning policy documents, and IRC technical guidelines. The review is structured to move from the global and theoretical to the specifically Indian and applied — culminating in a detailed analysis of three case studies that ground the conceptual and normative framework in documented practice. The chapter also identifies critical gaps in the existing literature that this thesis seeks to address.

#### 2.2 National Literature Review (Indian Context)

##### 2.2.1 The Scale of Child Road Safety Risk in India

India's road safety crisis is well-documented in terms of aggregate statistics, yet its specifically child-centric dimension has received comparatively limited systematic attention in planning literature. The MoRTH Road Accidents in India (2022) report documents 4,61,312 road accidents, 1,68,491 fatalities, and 4,43,366 injuries in that year alone, representing one of the highest absolute tolls in the world. Children between the ages of 5 and 14 — the primary school-going cohort — constitute a significant share of pedestrian fatalities, with the majority of these incidents occurring in urban areas during school-going hours.

The World Resources Institute (WRI) India's 'Safe Access to Schools' initiative (2021), launched in Bengaluru, provides one of the most systematic geo-spatial analyses of road safety conditions around schools. Using a web-based tool that integrates road safety data, school locations, and traffic flow, WRI India demonstrated that the density of schools and the severity of traffic hazards often spatially coincide, particularly in dense inner-city areas characterized by sub-arterial and collector roads with high mixed-traffic volumes (WRI India, 2021).

Research published by the Indian Journal of Community Medicine and similar journals underscores that children's injury vulnerability is rooted in developmental characteristics:

limited peripheral vision relative to adults, inability to accurately gauge vehicle speed at distances beyond 25–30 meters, susceptibility to distraction, and an underdeveloped capacity for rapid risk-assessment (Nanda et al., 2018). These characteristics make the built environment — the provision of safe crossing points, speed reduction infrastructure, and adequate sight lines — the most critical factor in school zone safety, more so than behavioural education alone.

The NIMHANS Advancing Child Safety in India report (Bengaluru chapter) remains a landmark empirical document in the Indian school zone discourse. Its findings, that a mere 11.5 per cent of schools had speed limit signs in their vicinity and only 17 per cent were served by roads with school zone signage, offer a sobering baseline against which the effectiveness of subsequent interventions must be measured (NIMHANS, cited in Citizen Matters, 2019).

### 2.2.2 Policy and Legal Framework in India

India's national approach to school zone safety is structured around several intersecting legislative and policy instruments:

**Motor Vehicles Amendment Act, 2019:** Introduced significantly higher penalties for traffic violations, including speeding near schools. Section 112 establishes speed limits for various road categories, and the Act empowers state governments to impose lower limits in sensitive zones. The amendment also introduces mandatory third-party insurance reforms and enables electronic surveillance for enforcement.

**National Road Safety Policy, 2010:** Establishes the multi-ministerial framework for road safety in India, emphasizing the 4Es — Engineering, Education, Enforcement, and Emergency Care. The policy explicitly identifies school zones as priority zones for road safety intervention and calls for dedicated institutional mechanisms at the state level.

**National Urban Transport Policy (NUTP), 2014:** Emphasizes walking and non-motorized transport as essential components of sustainable urban mobility, with pedestrian infrastructure quality identified as a critical planning objective. School zones, such as high-pedestrian-volume nodes, fall within the NUTP's operational scope.

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**AMRUT 2.0 and Smart Cities Mission:** Both centrally sponsored schemes include pedestrian and cycle infrastructure development as eligible components, with several Smart City proposals including school zone safety improvement as a component of the Integrated Command and Control Centre (ICCC) systems and smart signage programmes.

### 2.2.3 IRC Guidelines for School Zone Safety

The Indian Roads Congress is the apex technical body for road standards in India. The following IRC publications constitute the normative backbone of school zone safety planning:

| IRC Publication | Title                                                   | Relevance to School Zone Safety                                                                                                                                                                 |
|-----------------|---------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| IRC: SP:32-2023 | Road Safety for Children                                | Primary document defining School Proximal Zone (SPZ), School Transition Zone, School Access Zone; speed limits; signage; pavement markings; pick & drop provisions; pedestrian crossing design. |
| IRC:99-2018     | Guidelines for Traffic Calming Measures (Urban & Rural) | Specifies physical traffic calming devices — speed humps, raised crossings, chicanes, rumble strips — and their application in sensitive zones near schools and hospitals.                      |
| IRC:103-2012    | Guidelines for Pedestrian Facilities                    | Prescribes footpath widths, kerb ramp design, zebra crossing geometry (minimum 4m width on roads near schools), signal timing for pedestrian crossings, and bollard placement.                  |
| IRC:35-2015     | Code of Practice for Road Markings                      | Defines pavement marking standards including school zone markings, stop lines, zebra crossing patterns, and no-parking zone demarcation.                                                        |
| IRC:67-2012     | Code of Practice for Road Signs                         | Specifies mandatory, cautionary, and informatory sign types and placement protocols applicable in school zones.                                                                                 |

IRC: SP:32-2023 defines three spatial zones around a school gate:

- **School Proximal Zone (SPZ):** The immediate zone around the school gate, typically 50–100 meters radius, where the maximum level of traffic management intervention is required. A speed limit of 25 kmph is prescribed within the SPZ.
- **School Transition Zone:** The intermediate zone, extending to 300 metres from the school boundary, where speed reduction from the prevailing road speed limit to the SPZ speed limit is achieved through progressive traffic calming measures. Transition lengths range from 50 to 150 metres depending on the prevailing speed limit.

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- School Access Zone (SAZ): The broader zone within which students travel to access the school, typically defined by the nearest public transport stop or the edge of the school's pedestrian catchment. Safe walking and cycling routes within the SAZ are a key planning concern.

### IRC: SP:32-2023 — Key Prescriptions for School Proximal Zone

Speed limit: 25 kmph within the SPZ (maximum)

Warning signs: 'School Ahead' cautionary signs at the commencement of transition zone; 'School Speed Limit' signs at SPZ boundary

Pavement markings: Pedestrian crossing (zebra) markings, 'SLOW' or 'SCHOOL ZONE' pavement text, speed limit numerals

Pedestrian crossing: Minimum 4 metres wide; raised table-top crossings preferred near school gates

Pick-up/Drop-off: Designated bays separated from active carriageway; staggered access design to avoid queuing on road

Footpath: Minimum 1.5m clear width; 1.8m preferred; barrier separation from carriageway where space permits

Sight distance: Trees, parking, and street furniture to be managed to maintain unobstructed sight lines at crossings

## 2.3 International Literature Review

### 2.3.1 Global Frameworks and WHO Targets

The World Health Organization's Global Plan for the Decade of Action for Road Safety (2021–2030) establishes the global normative framework within which national school zone safety efforts are situated. The Decade of Action sets an aspirational target of reducing road traffic deaths and injuries by at least 50 per cent by 2030, with special attention to the safety of vulnerable road users — pedestrians, cyclists, and children. Goal 3 of the plan specifically addresses Safe Road Systems, calling for the universal implementation of appropriate speed management near schools, hospitals, and other sensitive facilities.

The Vision Zero approach, originating in Sweden (1997) and subsequently adopted in New York City, Oslo, Helsinki, and several other leading cities, establishes a fundamentally different ethical and planning premise: that no road death or serious injury is acceptable, and that the road system must be designed to accommodate human error. Within Vision Zero frameworks, school zones represent the highest-priority intervention locations, where

the combination of vulnerable users and predictable, concentrated pedestrian flow creates the most tractable opportunity for life-saving design.

A systematic review of school zone safety interventions published in *Safety Science* (2020) synthesized findings from 53 international studies, concluding that infrastructure-based interventions — speed humps, raised crossings, signal upgrades, and footpath improvements — demonstrate the most consistent and durable safety benefits, while education-based interventions show positive short-term effects that tend to diminish without reinforcement (*Safety Science / ScienceDirect*, 2020).

### **2.3.2 Behavioral and Environmental Risk Factors**

The international literature consistently identifies the following risk factors in school zone environments:

- Vehicle speed as the primary determinant of injury severity: The probability of fatal injury to a pedestrian struck by a vehicle at 50 kmph is approximately 80 per cent; at 30 kmph this falls to 10 per cent (IRC:99-2018, citing WHO data). Speed management is therefore the single highest-priority intervention in school zones.
- Temporal concentration of risk: School arrival and dispersal hours see a five to eight-fold increase in pedestrian density in the school zone. Infrastructure must be designed for peak-hour conditions even if these persist for only 30–45 minutes twice daily.
- Age-related vulnerability: Children under the age of 9 lack the perceptual and cognitive capacity to safely self-manage road crossing in unsupervised conditions (Petzoldt, 2014). This underscores the need for supervised crossings and physical infrastructure that reduces the decisions children must make.
- The role of the built environment: Studies across the UK, Australia, and the United States demonstrate that the presence of footpaths, raised crossings, and speed humps within 300 metres of a school is associated with statistically significant reductions in pedestrian injury rates.

## 2.4 Case Study 1 — Indian Context

### CASE STUDY 1: St. Joseph's School Safe Zone, Bengaluru, Karnataka

| Parameter                     | Details                                                                                               |
|-------------------------------|-------------------------------------------------------------------------------------------------------|
| <b>Location</b>               | St. Joseph's School (CBSE), Shivajinagar, Bengaluru, Karnataka                                        |
| <b>Implementing Partners</b>  | 3M India (Corporate Sponsor), Concern for Road and Pedestrian Safety (CoRPS), United Way of Bengaluru |
| <b>Programme</b>              | Young Change Agents for Road Safety (YCARS)                                                           |
| <b>Year of Implementation</b> | November 2019 (Pilot); Expanded 2021                                                                  |
| <b>Road Classification</b>    | Sub-arterial and collector roads; high mixed-traffic volume                                           |
| <b>IRC Alignment</b>          | IRC: SP:32-2023, IRC:35-2015, IRC:67-2012                                                             |

#### 2.4.1 Context and Problem Identification

St. Joseph's School in Bengaluru's Shivajinagar neighbourhood is situated on a busy sub-arterial road characterized by high volumes of mixed motorized traffic, including buses, two-wheelers, and private cars. Prior to the intervention, the school zone lacked designated school zone signage, pavement markings, and safe pedestrian crossing facilities. Students — predominantly aged 6 to 17 — navigated active traffic lanes without infrastructure protection during arrival and dispersal hours. BBMP (Bruhat Bengaluru Mahanagara Palike) road maintenance in the zone was also inadequate, with potholes and irregular kerb conditions further deteriorating the walking environment.

The YCARS programme, launched by 3M India in partnership with CoRPS and United Way of Bengaluru, adopted a participatory approach to school zone safety improvement. A distinguishing feature of the methodology was its engagement of students themselves as safety auditors — conducting systematic assessments of hazard conditions in their own school zones, mapping problem areas, and contributing to the design of improvement measures. This student-centred approach generated not only infrastructure improvements but also a measurable shift in road safety awareness among participating children, parents, and school staff.

### 2.4.2 Interventions Implemented

The School Safety Zone established at St. Joseph's School encompassed the following infrastructure and management measures, directly aligned with IRC prescriptions:

- IRC: SP:32 Aligned Signage: 'Slow Down – School Ahead' warning signs installed at the transition zone boundary; speed limit signs (25 kmph) placed at the School Proximal Zone entry.
- Pavement Markings: Zebra crossing stripes repainted at the primary school gate access point; 'SLOW SCHOOL ZONE' pavement text stencilled on the carriageway approach.
- Traffic Channelization: Temporary traffic channelization measures implemented during arrival and dispersal hours to segregate pick-up/drop-off vehicles from through-traffic.
- Footpath Clearance: Street furniture and encroachments removed from the pedestrian walkway to restore IRC:103-compliant clear width of 1.5 metres
- Student-Led Safety Audits: Structured audit checklists based on IRC: SP:32 parameters were completed by student groups as part of the YCARS programme's educational component.

### 2.4.3 Outcomes and Lessons

The Bengaluru intervention demonstrated the viability of CSR-funded, community-led school zone safety improvement within the Indian institutional context. Key outcomes included:

- Measurable improvement in road user awareness and compliance around the school gate area, as observed during post-implementation monitoring.
- Replication at 5 schools in Pune and 4 schools in Bengaluru within two years, with plans to scale to 15–20 schools across five cities (Bengaluru, Delhi, Mumbai, Chennai, Pune) in subsequent phases (Citizen Matters / Business Standard, 2021).
- Demonstrated potential for inter-institutional collaboration: the involvement of BBMP road safety consultants alongside civil society and corporate partners established a template for coordinated school zone improvement.

## SCHOOL ZONE SAFETY

### Lessons for Planning Practice — Bengaluru Case

CSR funding, when channelled through structured programmes, can operationalize IRC prescriptions at school level.

Student participation in safety audits creates durable awareness and community ownership of safety infrastructure.

Signage and pavement marking improvements can be implemented at low cost and generate immediate risk-reduction benefits.

Sustained impact requires institutional uptake by municipal bodies; NGO/CSR-led interventions alone are insufficient for systemic change.

Scaling requires government endorsement and integration of school zone safety into urban local body (ULB) road maintenance cycles.

### 2.4.4 Limitations

- The pilot was limited to a small number of schools; system-wide change requires municipal mandate and resources beyond CSR.
- Physical improvements were not accompanied by formal traffic regulation orders enforcing the 25 kmph speed limit, limiting the effectiveness of speed management.
- Long-term monitoring data to assess accident reduction outcomes was not publicly available at the time of this review.

## 2.5 Case Study 2 — Indian Context

### CASE STUDY 2: New Delhi Safe School Zone (250 Meters of Happiness)

| Parameter              | Details                                                                                                               |
|------------------------|-----------------------------------------------------------------------------------------------------------------------|
| Location               | Deen Dayal Upadhyaya (DDU) Marg (proximal to Mandir Marg and Asaf Ali Intersection), New Delhi                        |
| Implementing Partners  | HumanQind Design Foundation, Transport Department (GNCTD), TRIP Centre (IIT Delhi), and Public Works Department (PWD) |
| Programme              | CROSSWALK Initiative / Safe School Zone Initiative                                                                    |
| Year of Implementation | Pilot designed in 2019; Full implementation completed by 2024                                                         |
| Road Classification    | High-volume arterial/sub-arterial network in Central Delhi                                                            |

|               |                                                                                      |
|---------------|--------------------------------------------------------------------------------------|
| IRC Alignment | Designed as per Indian Roads Congress (IRC) Standards (specifically IRC: SP:32-2023) |
|---------------|--------------------------------------------------------------------------------------|

### 2.5.1 Context and Problem Identification

The intervention targeted a critical school cluster in New Delhi, including DAV Public School and several government schools (GGSSS, GBSSS, and RBVP). Prior to the intervention, the environment was characterized by high-speed transit traffic, a lack of pedestrian agency, and fragmented infrastructure. Data cited in the study indicated that approximately 45 children die daily in India due to road crashes, often near school areas where they have "no say" in decision-making.

The project utilized the **CROSSWALK Initiative** model, a compassion-centered design process. A distinguishing feature was the engagement of a single classroom of 50 students who acted as the primary designers. Through 10 workshops and "design co-labs," students conducted data collection and mapped their lived experiences to transform them into engineering solutions. This participatory approach aimed to build physical safety while creating a scalable blueprint for "Safe School Zones" across Delhi.

### 2.5.2 Interventions Implemented

The project, titled "**250 Meters of Happiness**," implemented a comprehensive suite of "Space to Place" interventions across a 250m stretch, directly aligned with IRC: SP:32-2023 prescriptions:

- **Speed Management & Crossings:** Implementation of **raised crossings** to force vehicular speed reduction and provide level-surface pedestrian movement across the carriageway.
- **Infrastructure Segregation:** Installation of **bollards** and multi-utility zones to protect footpaths and segregate a shared cycle track from motorized lanes.
- **Child-Centric Urbanism:** Inclusion of street wall art, glass mosaic artwork, and dedicated **play areas** within the school zone to improve the psychological "wellbeing" of students.
- **Street Furniture & Amenities:** Integration of organized vendor zones, waiting areas for parents/students, and improved street furniture to prevent footpaths from being obstructed.
- **Signage and Markings:** Systematic installation of high-visibility road signs and pavement markings to define the School Proximal Zone.

## 2.5.3 Outcomes and Lessons

The initiative transformed a high-risk transit corridor into a child-friendly public space. Key outcomes include:

- **Direct Impact:** While designed by 50 students, the infrastructure now serves over 10,000 children who share this school cluster.
- **Institutional Integration:** The project successfully transitioned from a tactical pilot to a permanent implementation by the Public Works Department (PWD), demonstrating a successful hand-off from civil society to government agencies.
- **Community Leadership:** Established "Road Safety Clubs" to manage the zone, giving students a long-term role in maintaining their environment.

### Lessons for Planning Practice — New Delhi Case

Co-creation works: Children can identify specific hazards (e.g., specific gate risks) that professional auditors might overlook.

Holistic Design: Safety is not just about speed; integrating play, art, and vendor zones ensures the space is used as intended and respected by drivers.

Inter-agency coordination: Success requires a formal partnership between transport departments (policy), PWD (execution), and academic bodies like TRIP Centre (evidence).

## 2.5.4 Limitations

- **Scalability Constraints:** The intensive co-design process (multiple 90-minute workshops) may be difficult to replicate across thousands of schools without significant human resource investment.
- **Temporal Challenges:** The transition from the 2019 pilot design to the 2024 implementation highlights the long lead times often required for permanent street transformations in Indian cities.
- **Maintenance:** Long-term success depends on the sustained activity of student "Road Safety Clubs" and the durability of artistic elements like glass mosaics against heavy weather and traffic.

## 2.6 Case Study 3 — International Context

### CASE STUDY 3: Safe Routes to School (SRTS) Programme — New York City, USA

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| Parameter           | Details                                                                                                |
|---------------------|--------------------------------------------------------------------------------------------------------|
| Location            | New York City (NYC), United States of America                                                          |
| Implementing Agency | New York City Department of Transportation (NYCDOT); funded by the 2005 federal SAFETEA-LU Act         |
| Programme           | Safe Routes to School (SRTS) Programme — NYC Implementation                                            |
| Period              | 2005–2013 (primary implementation phase); ongoing extensions                                           |
| Scale               | Safety improvements at over 100 public schools in high-risk census tracts across all five NYC boroughs |
| Funding             | \$10 million (primary phase); federal SRTS allocation under SAFETEA-LU                                 |

### 2.6.1 Programme Context and Approach

The Safe Routes to School (SRTS) programme in the United States was formally established under the 2005 SAFETEA-LU federal transportation legislation, which allocated \$612 million nationally to create safer environments for children walking or cycling to school. New York City's implementation of SRTS, led by the NYC Department of Transportation under Commissioner Janette Sadik-Khan during the Bloomberg administration, became one of the most rigorously documented and cited case studies in school zone safety literature globally.

NYC's SRTS programme targeted the highest-risk school-adjacent intersections in the city in dense urban census tracts with elevated child pedestrian injury rates. The intervention methodology was systematically applied across more than 100 public schools located in high-risk zones. Critically, the programme prioritized engineering and physical infrastructure improvements (70–90 per cent of funding), supplemented by education, enforcement, and encouragement components (10–30 per cent).

### 2.6.2 Interventions Implemented

NYC SRTS interventions encompassed a comprehensive range of engineering and traffic management measures:

- Intersection Kerb Extensions (Bulb-outs): Widening of footpaths into the parking lane at crossings to shorten the pedestrian crossing distance, improve pedestrian visibility, and reduce vehicle speed at the crossing point.

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- **Speed Humps and Raised Crossings:** Installation of speed humps on approaches to school crossings to enforce speed reduction. Raised table-top crossings at school gates elevated the crossing to footpath level, prioritizing pedestrian movement over vehicles.
- **Upgraded Pedestrian Signals:** Installation of new pedestrian signals with Leading Pedestrian Intervals (LPIs) that give pedestrians a 7-second head start before vehicles receive a green signal, substantially reducing pedestrian-turning vehicle conflicts.
- **Bicycle Lanes:** Designation and physical demarcation of protected bicycle lanes on routes serving schools, providing an alternative active travel mode with separation from motorized traffic.
- **Traffic Signal Timing:** Re-timing of signals to increase pedestrian crossing time, particularly at intersections with high proportions of elderly and child pedestrians.
- **Signage and Pavement Markings:** Comprehensive school zone signage with fluorescent warning signs, school speed limit markings, and enhanced zebra crossing geometry at all school-adjacent crossings.

### 2.6.3 Outcomes and Evidence

The NYC SRTS programme is distinguished by the quality of its outcome evidence, with multiple peer-reviewed studies published in leading public health and transportation journals providing rigorous before-and-after analyses:

- **Pedestrian Injury Reduction:** A study published in *Pediatrics* (DiMaggio & Li, 2013) found that implementation of SRTS reduced school-aged pedestrian injury rates by 44 per cent in census tracts with SRTS interventions, compared to census tracts without interventions — a statistically significant and substantial reduction (PMC, 2013).
- **Cost-Effectiveness:** A cost-effectiveness analysis published in the *American Journal of Public Health* (Muennig et al., 2014) found that the \$10 million investment in SRTS infrastructure in NYC generated a projected net societal benefit of \$230 million over the 50-year useful life of the infrastructure improvements, while also generating 2,055 quality-adjusted life years (QALYs) gained. The programme was found to 'dominate' the no-investment alternative — saving both money and lives (Columbia University Mailman School of Public Health, 2014).
- **National Evidence:** A nationwide study across 18 US states over 16 years (DiMaggio et al., 2016) associated SRTS with a 23 per cent reduction in pedestrian/bicyclist injury

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risk and a 20 per cent reduction in fatality risk in school-age children, controlling for trends in adult injury rates (NHTSA, 2016).

### Quantified Outcomes — NYC Safe Routes to School Programme

44% reduction in school-aged pedestrian injury rates in SRTS intervention census tracts (DiMaggio & Li, 2013)

33% overall reduction in annual pedestrian injury rates among 5–19 year olds during the study period

\$230 million projected net societal benefit from \$10 million investment over 50-year infrastructure life

2,055 quality-adjusted life years (QALYs) gained from the programme's interventions

Interventions covered 100+ public schools across NYC's five boroughs in the highest-risk census tracts

Programme found to 'dominate' no-investment alternative — saves both money and lives

### 2.6.4 Transferable Lessons for Indian School Zone Planning

While the institutional, legal, and financial context of NYC's SRTS programme differs significantly from the Indian setting, several lessons are directly transferable:

- **Engineering-First Approach:** The primacy of physical infrastructure investment (70–90 per cent of SRTS funding) over softer interventions confirms the IRC's emphasis on built environment improvement as the foundation of school zone safety — a lesson directly applicable to Indian urban contexts where behavioural programmes have historically received disproportionate attention.
- **Evidence-Based Prioritization:** NYC's use of geocoded crash data to identify and rank high-risk school intersections mirrors the potential of India's VAHAN database and state road accident data systems for systematic school zone risk mapping — a methodology that WRI India has begun to operationalize in Bengaluru.
- **Cost-Effectiveness Argument:** The SRTS cost-benefit evidence base provides a template for making the economic case for school zone investment to Indian municipal corporations and state finance departments, where capital budget constraints are significant.

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- **Active Travel Integration:** SRTS's explicit linkage of safety improvement to encouraging walking and cycling to school is directly aligned with India's NUTP and AMRUT goals, creating a multi-benefit rationale for school zone investment.
- **Systemic Programme vs. Ad Hoc Projects:** NYC's city-wide, systematically prioritized and monitored programme structure — as opposed to individual school-level projects — is the institutional model India's metropolitan cities should aspire to, as it ensures equity of investment across income groups and geographic areas.

### 2.6.5 Limitations and Contextual Differences

- New York City's per-capita road infrastructure investment capacity is orders of magnitude greater than Indian municipal corporations; direct cost replication is not feasible.
- NYC's relatively homogeneous motorized traffic environment (predominantly cars) differs from India's heterogeneous mixed-traffic context, where two-wheelers, auto-rickshaws, and non-motorized vehicles interact with pedestrians at school zones.
- NYC's mature traffic signal infrastructure and enforcement capacity does not have a direct parallel in most Indian cities, limiting the immediate applicability of signal-based interventions.

## 2.7 Comparative Analysis of Case Studies

| Parameter              | Case Study 1:<br>Bengaluru             | Case Study 2:<br>New Delhi               | Case Study 3:<br>New York City    |
|------------------------|----------------------------------------|------------------------------------------|-----------------------------------|
| Scale                  | School-level; 5–10 schools             | Cluster-level; 250m stretch              | City-wide; 100+ schools           |
| Road Type              | Urban sub-arterial/collector           | High-volume arterial                     | Urban mixed streets               |
| Primary Intervention   | Signage, markings, participatory audit | Tactical urbanism, raised crossings, art | Comprehensive engineering package |
| IRC/Standard Alignment | IRC: SP:32, IRC:35, IRC:67             | IRC: SP:32-2023                          | NACTO; US MUTCD                   |
| Funding Mechanism      | CSR + NGO                              | State (GNCTD) Govt + PWD                 | Federal SRTS allocation           |
| Institutional Lead     | NGO/Corporate partnership              | HumanQind + PWD + TRIP                   | City DOT                          |

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|                         |                              |                                     |                             |
|-------------------------|------------------------------|-------------------------------------|-----------------------------|
| <b>Measured Outcome</b> | Awareness; Safety compliance | Permanent infrastructure; wellbeing | 44% injury reduction        |
| <b>Scalability</b>      | Moderate (Requires CSR)      | Moderate (Intensive co-design)      | High (Systematic programme) |

## 2.8 Research Gaps and Personal Insights

### 2.8.1 Research Gaps Identified

The review of national and international literature reveals several important gaps in the field of school zone safety planning. Although technical standards and policy frameworks exist, their systematic application and evaluation at the local level remain limited. In the Indian context, most documented interventions are pilot-based initiatives concentrated in metropolitan cities, with limited empirical evidence from medium-sized cities such as Bhopal. This creates a geographical research imbalance and restricts contextual understanding of school zone safety challenges outside major urban centers.

Another significant difference is the absence of structured compliance assessment studies that directly evaluate existing school environments against prescribed technical standards such as IRC: SP:32-2023. While guidelines specify measurable parameters including speed limits, raised crossings, signage placement, and minimum pedestrian clear width, few studies conduct systematic on-ground audits to determine the extent of adherence.

There is also limited integration of spatial tools such as GIS mapping for identifying conflict points, pedestrian movement patterns, and high-risk intersections within school zones. Most research remains descriptive rather than spatially analytical.

Additionally, perception-based assessment of safety among students, parents, and school authorities is often underrepresented in engineering-led studies. Understanding behavioural risk exposure and subjective safety perception is essential for holistic planning, yet it is not consistently incorporated into evaluation frameworks.

Finally, long-term monitoring of intervention outcomes, particularly accident reduction data and sustained compliance levels, remains insufficient in the Indian context. Many initiatives report implementation outputs but lack post-implementation impact evaluation. These research gaps collectively justify the need for a structured, location-specific, audit-based study in Shivaji Nagar, Bhopal.

### 2.8.2 Best Practices Emerging from the Literature

The literature and case studies reviewed highlight several best practices that are consistently associated with improved school zone safety outcomes. A central finding

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across both national and international contexts is the critical role of speed management. Establishing and enforcing low speed limits, particularly 25–30 kmph within the School Proximal Zone, significantly reduces the severity and probability of pedestrian injuries.

The provision of raised pedestrian crossings near school gates emerges as a highly effective engineering measure. Raised tables function both as a crossing facility and as a traffic calming device, compelling drivers to reduce speed while improving pedestrian visibility.

Clear and standardized signage and pavement markings are also essential components of effective school zone design. Visible school warning signs, speed limit boards, thermoplastic zebra crossings, and carriageway text markings improve driver awareness and compliance.

Continuous, obstruction-free footpaths with adequate clear width are identified as fundamental to child pedestrian safety. The removal of encroachments and proper kerb design enhances both accessibility and visibility.

Structured pick-up and drop-off management systems, including designated bays and traffic channelization during peak hours, reduce conflict between traffic and school-related vehicles.

The literature further emphasizes the importance of multi-stakeholder collaboration. Successful interventions often involve coordination between municipal authorities, traffic police, school administrations, civil society organizations, and community groups. Participatory approaches, including student-led safety audits, contribute to long-term awareness and behavioural change.

Collectively, these best practices underscore that effective school zone safety requires an integrated approach combining engineering measures, regulatory enforcement, community participation, and institutional coordination. These insights directly inform the planning framework adopted in the present thesis.

### **2.8.3 Implications for This Thesis**

The identified research gaps and best practices directly shape the direction and methodology of this thesis. Specifically:

- The thesis will conduct a systematic IRC: SP:32-aligned safety audit of school zones in the study area, contributing to the evidence base for school zone conditions.
- The research will assess the institutional and governance dimensions of school zone safety management in the study area, identifying specific inter-agency coordination failures.

- Recommendations will follow the 4E framework, integrating engineering, education, enforcement, and encouragement components within a unified planning proposal.
- The methodology will be designed to generate data usable for future longitudinal assessment, thereby contributing to the evidence base that this review identifies as currently absent.

### 2.9 Methodology

This study adopts a **mixed-method approach** combining primary field investigations, secondary data review, spatial analysis, and perception-based assessment to achieve the stated objectives. The methodology is designed to ensure alignment between each objective and the corresponding data collection and analytical technique, thereby providing a comprehensive and evidence-based evaluation of school zone safety in Shivaji Nagar, Bhopal.

#### Data Sources:

- **Primary data** includes on-site infrastructure audits, traffic volume counts, spot speed studies, pedestrian movement observations, and questionnaire surveys administered to students, parents, and school authorities.
- **Secondary data** comprises national technical guidelines (IRC SP:32, MoRTH manuals), municipal records, published reports, census data, and relevant case studies.
- **Spatial data** is obtained through base maps, satellite imagery, and field measurements.

#### Analytical Tools and Methods:

- **Geographic Information System (GIS):** Used for mapping school zone boundaries, pedestrian routes, conflict points, and infrastructure gaps.
- **Statistical tools:** Applied to analyze survey responses, speed data, and compliance indices.
- **Compliance-based evaluation framework:** Developed to compare existing conditions with IRC-prescribed standards.
- **Perception analysis:** Conducted using structured questionnaires and Likert-scale interpretation to capture child and stakeholder perspectives.

**Justification:** The chosen tools and methods are supported by literature emphasizing the importance of integrating **engineering assessment, behavioural analysis, and spatial**

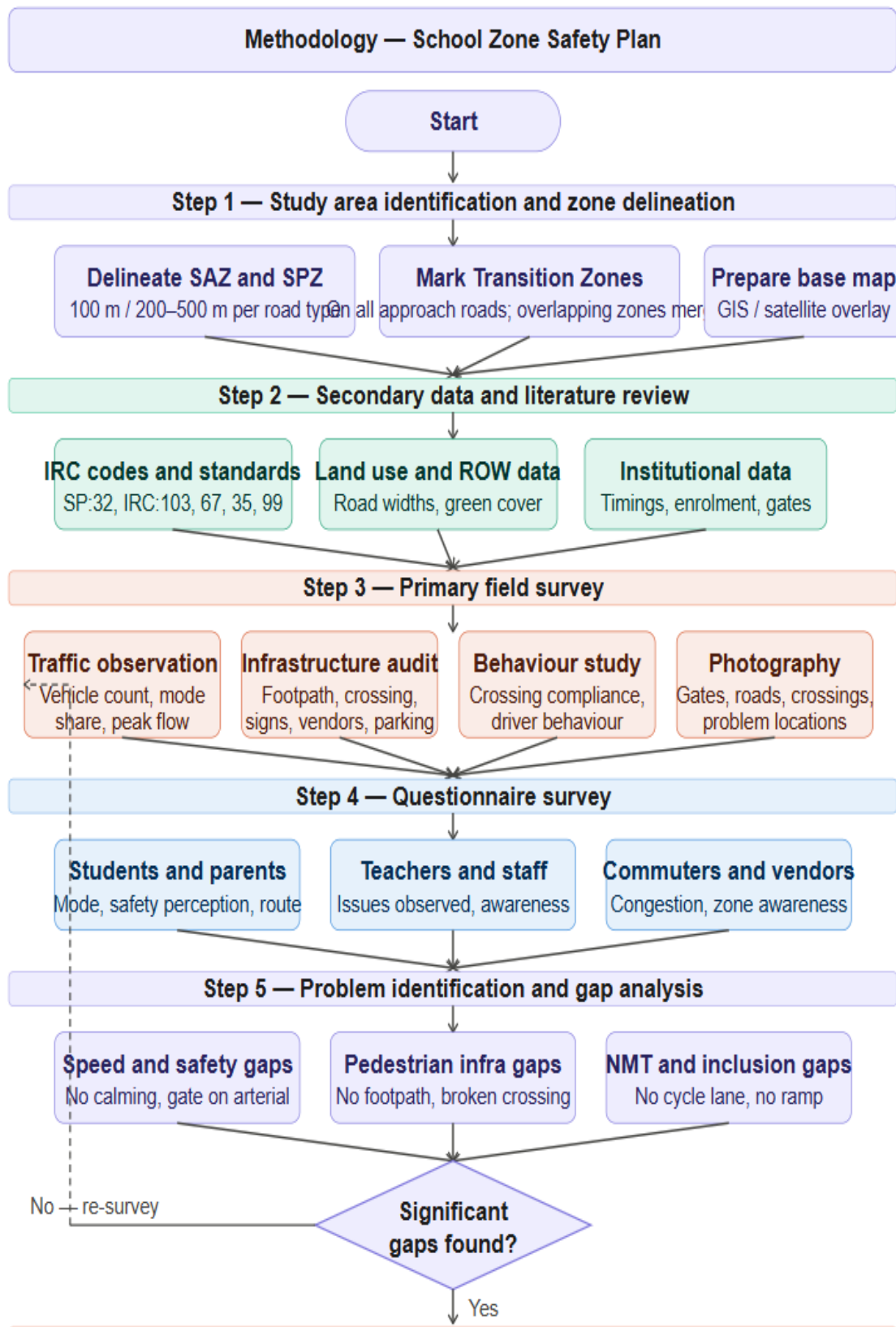
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**evaluation** for effective school zone planning. GIS enables spatial visualization of risks, speed surveys provide quantitative evidence of compliance, and perception surveys highlight user-centric concerns. Together, these approaches ensure a balanced methodology that addresses infrastructure, enforcement, and behavioural dimensions.

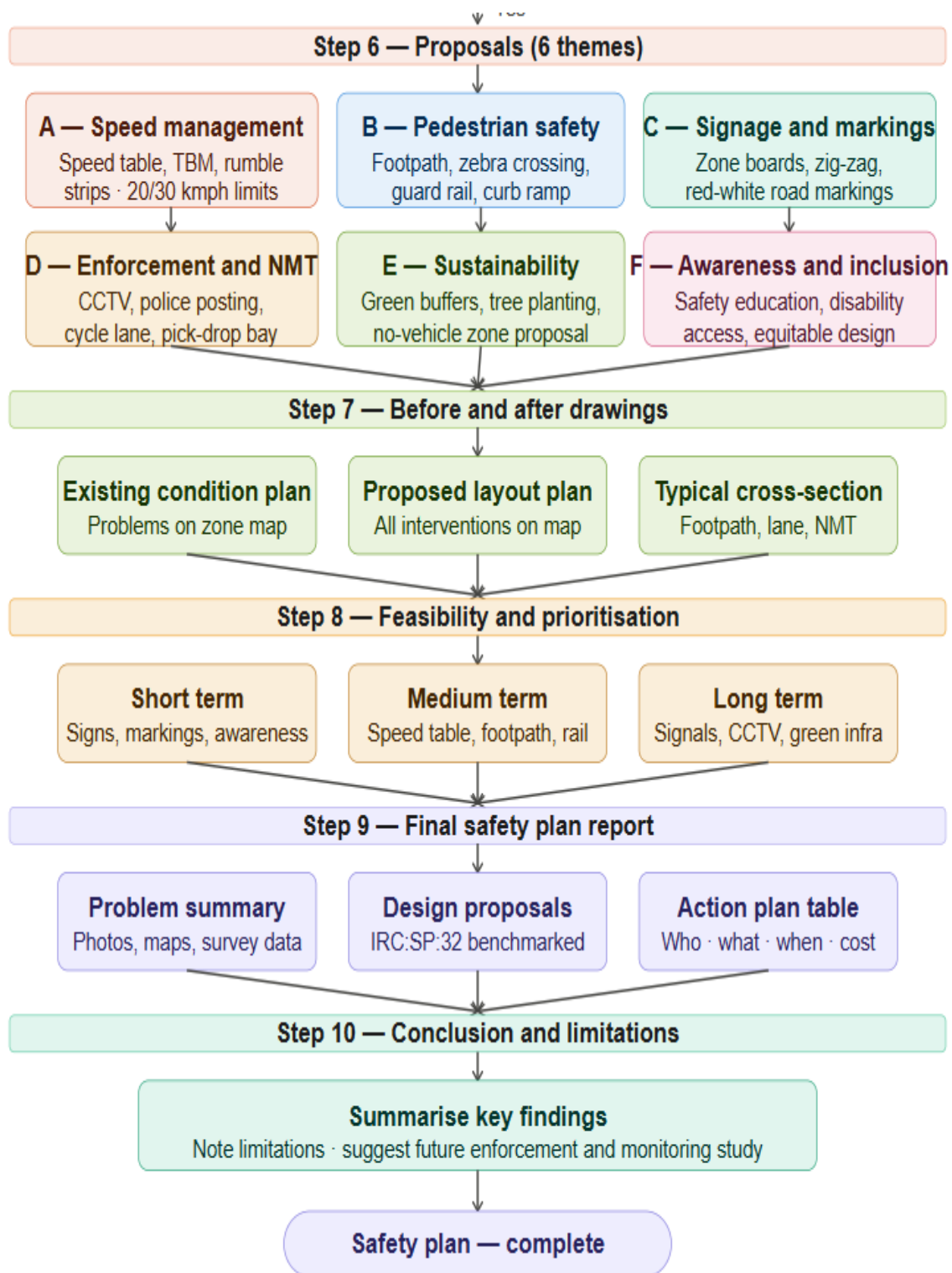
### **Objective-wise Methods:**

- **Uniform Speed Management:** Spot speed surveys during peak school hours; statistical analysis of mean speeds and compliance with IRC limits.
- **Pedestrian Safety Infrastructure:** Structured audits of footpaths, crossings, kerb ramps, and guard rails; compliance index against IRC dimensional standards.
- **School Zone Delineation:** Field surveys of signage and markings; GIS mapping of proximal and transition zones within 300–500 m radius.
- **Enforcement Mechanisms:** Observation of traffic police presence, CCTV coverage, and stakeholder interviews; qualitative analysis of enforcement adequacy.
- **Non-Motorized Mobility:** Pedestrian and cycling counts; GIS mapping of walking/cycling routes; gap analysis of connectivity.
- **Environmental Sustainability:** Observation of congestion, vehicular accumulation, and green buffers; qualitative assessment of emission reduction potential.
- **Social Inclusivity and Awareness:** Surveys of students, parents, and teachers; analysis of accessibility features and perception data.

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### 2.10 Conclusion

The literature review establishes that school zone safety is a critical component of urban transport planning, particularly in the context of child vulnerability within mixed-traffic environments. Both national and international studies consistently highlight that excessive vehicle speed, inadequate pedestrian infrastructure, unclear zone delineation, weak enforcement, and limited community engagement are the primary contributors to unsafe school environments.

In the Indian context, while technical standards and policy frameworks provide clear design and management prescriptions, implementation remains fragmented and inconsistent. Case studies demonstrate that low-cost engineering measures such as raised pedestrian crossings, standardized signage, speed calming devices, and structured pick-up and drop-off management can significantly enhance safety when properly executed. However, most documented interventions are pilot-based and lack long-term institutional integration and systematic monitoring.

International experiences further reinforce the importance of integrated approaches combining engineering design, enforcement, behavioural awareness, and sustainable mobility promotion. The emphasis on speed management, non-motorized transport infrastructure, and participatory planning offers valuable lessons adaptable to Indian urban conditions.

The review also identifies clear research gaps, particularly the absence of micro-level compliance assessments in medium-sized cities and the limited integration of spatial analysis and perception-based data. These gaps justify the need for a structured, field-based, guideline-aligned evaluation of school zones in Shivaji Nagar, Bhopal.

Overall, the literature confirms that effective school zone planning requires a coordinated, multi-dimensional approach that integrates infrastructure design, regulatory enforcement, community participation, and environmental considerations. These insights form the conceptual and analytical foundation for the subsequent empirical assessment presented in this thesis.

## CHAPTER 3

### Analysis and Findings

#### 3.1 Introduction to the Analysis

This chapter presents the detailed analysis and interpretation of the data collected during the field surveys and observational studies conducted in the Shivaji Nagar institutional cluster of Bhopal. The purpose of this chapter is to examine the existing mobility patterns, safety perceptions, and infrastructure conditions associated with the school zone environment and to identify the key safety challenges affecting students and other road users.

The analysis is primarily based on primary data collected through structured questionnaire surveys administered across five educational institutions located within the study area. These institutions include Subhash Excellence Government Higher Secondary School, Kendriya Vidyalaya No. 2, Sarojini Naidu Government Girls Higher Secondary School, Government Women's Polytechnic College, and Nutan College. The inclusion of multiple institutions within the same neighborhood allows the study to capture diverse travel behaviour patterns and safety concerns across different age groups and user categories.

A total of 329 valid responses were obtained during the survey, including 269 responses from students and 60 responses from teaching staff. The student respondents represent a wide age range, extending from primary school level to undergraduate education. This diverse sample provides a comprehensive understanding of travel behaviour, levels of independence in commuting, and exposure to traffic risks in the school zone environment.

In addition to questionnaire surveys, field observations were conducted during peak school arrival and dispersal hours in order to assess real-time traffic conditions, pedestrian movement patterns, and the physical characteristics of the surrounding road environment. Observations focused on elements such as vehicle speeds, congestion levels, pedestrian infrastructure availability, and pick-up and drop-off management near school entrances.

The data collected was analyzed using descriptive statistical techniques supported by graphical representation of results through charts and tables. These visual representations help illustrate patterns in travel behaviour, safety perceptions, and reported incidents within the study area. In addition, spatial analysis was undertaken to identify locations where conflicts between pedestrians and vehicles occur most frequently. Mapping of pedestrian routes, school entrances, and infrastructure gaps further helped in identifying high-risk areas requiring planning intervention.

The analysis presented in this chapter is organised into several thematic sections. The chapter begins with an overview of the respondent profile, followed by an examination of

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travel behaviour patterns among students and teachers. Subsequent sections analyse accompaniment patterns, traffic conditions, safety perceptions, accident exposure, and infrastructure availability. Spatial analysis is also conducted to identify conflict zones and areas lacking adequate pedestrian facilities. These analytical components collectively contribute to the identification of key planning issues affecting school zone safety in the study area.

The findings derived from this chapter form the analytical foundation for the planning proposals and design recommendations presented in the following chapter. By systematically examining both user perceptions and physical infrastructure conditions, this chapter provides a comprehensive understanding of the challenges associated with creating safe and child-friendly school zones in the urban context of Bhopal.

### 3.2 Study Area and Institutional Context

The study area for this research is located within the Shivaji Nagar institutional cluster in Bhopal, Madhya Pradesh. This area represents one of the important educational hubs of the city and accommodates several government schools and higher education institutions within a relatively compact urban setting. Due to the concentration of educational facilities and the high daily movement of students, teachers, and parents, the area experiences significant pedestrian and vehicular activity, particularly during school arrival and dispersal hours.

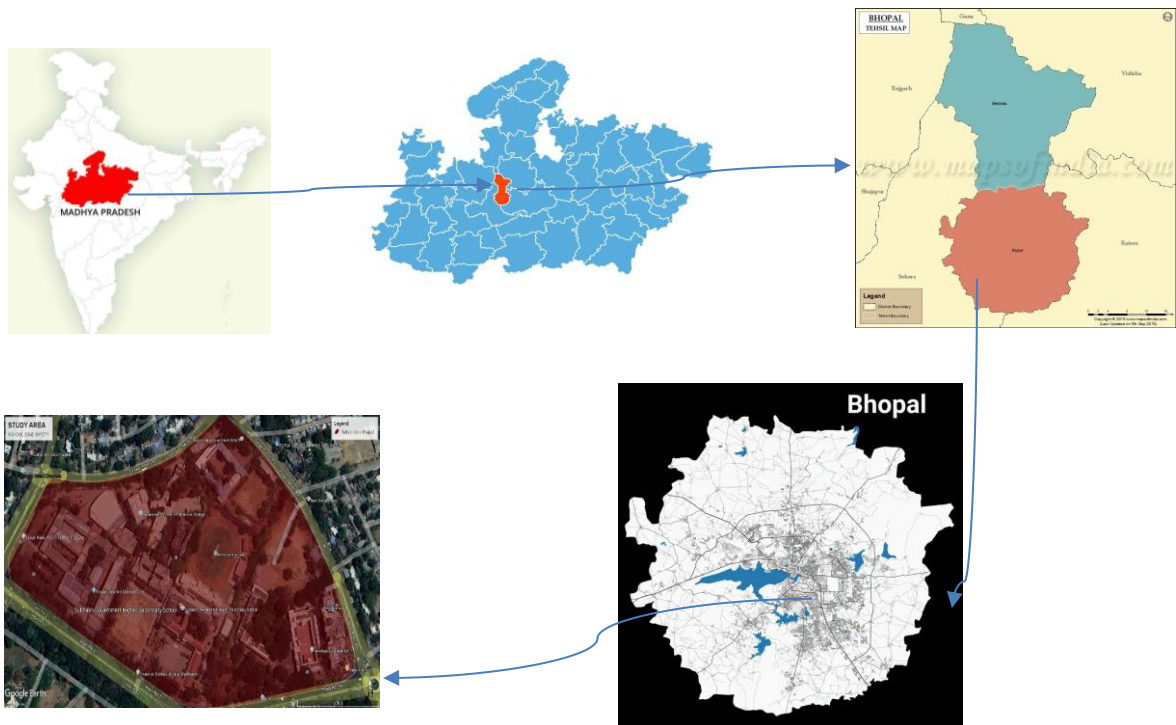


Fig. 1 Site Location

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The presence of multiple institutions within close proximity results in overlapping travel routes and shared road infrastructure. As a result, the surrounding streets function as major access corridors for students of different age groups, ranging from primary school children to college students. This concentration of daily educational travel makes the area highly suitable for examining the dynamics of school zone safety, travel behaviour, and pedestrian infrastructure conditions.

### **3.2.1 Educational Institutions in the Study Area**

The analysis includes five major educational institutions located within the Shivaji Nagar cluster. These institutions were selected to capture a diverse range of student age groups and commuting patterns. The institutions included in the study are:

- Subhash Excellence Government Higher Secondary School
- Kendriya Vidyalaya No. 2
- Sarojini Naidu Government Girls Higher Secondary School
- Government Women's Polytechnic College
- Nutan College

Together, these institutions generate a large daily movement of students and staff. The presence of both school-level and higher education institutions creates varied commuting patterns including walking, cycling, use of private vehicles, auto-rickshaws, and public transport.

The concentration of these institutions also leads to significant traffic interactions between pedestrians, school buses, private vehicles, and informal transport services. During peak school hours, the surrounding roads experience increased congestion, informal parking, and conflicts between pedestrians and moving vehicles.

### **3.2.2 Road Network and Accessibility**

The institutional cluster is connected by a network of local and collector roads that serve as the primary access routes to the schools and colleges. These roads accommodate mixed traffic conditions including two-wheelers, cars, auto-rickshaws, buses, and pedestrian movement.

The road network surrounding the institutions plays a crucial role in determining the safety and accessibility of the school zone. However, field observations indicate that several road segments lack continuous pedestrian infrastructure such as footpaths and designated crossing facilities. In many locations, pedestrians are required to share road space with moving vehicles, increasing the risk of conflicts and accidents.

During peak school hours, the absence of organized drop-off and pick-up zones further contributes to traffic congestion and unsafe pedestrian conditions. Informal stopping of

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vehicles near school gates often leads to obstruction of traffic flow and reduced visibility for pedestrians attempting to cross the road.

### 3.2.3 Land Use Characteristics

The land use pattern surrounding the institutional cluster consists primarily of educational, residential, and commercial activities. The presence of residential neighborhoods near the schools encourages walking and cycling among students who live nearby. At the same time, commercial establishments such as small shops, food vendors, and stationery stores generate additional pedestrian activity around school entrances.

This mixed land use environment contributes to the vibrancy of the area but also increases the complexity of traffic interactions. The overlap between educational travel and local commercial activity results in higher pedestrian volumes and frequent roadside activity, particularly during school opening and closing hours.

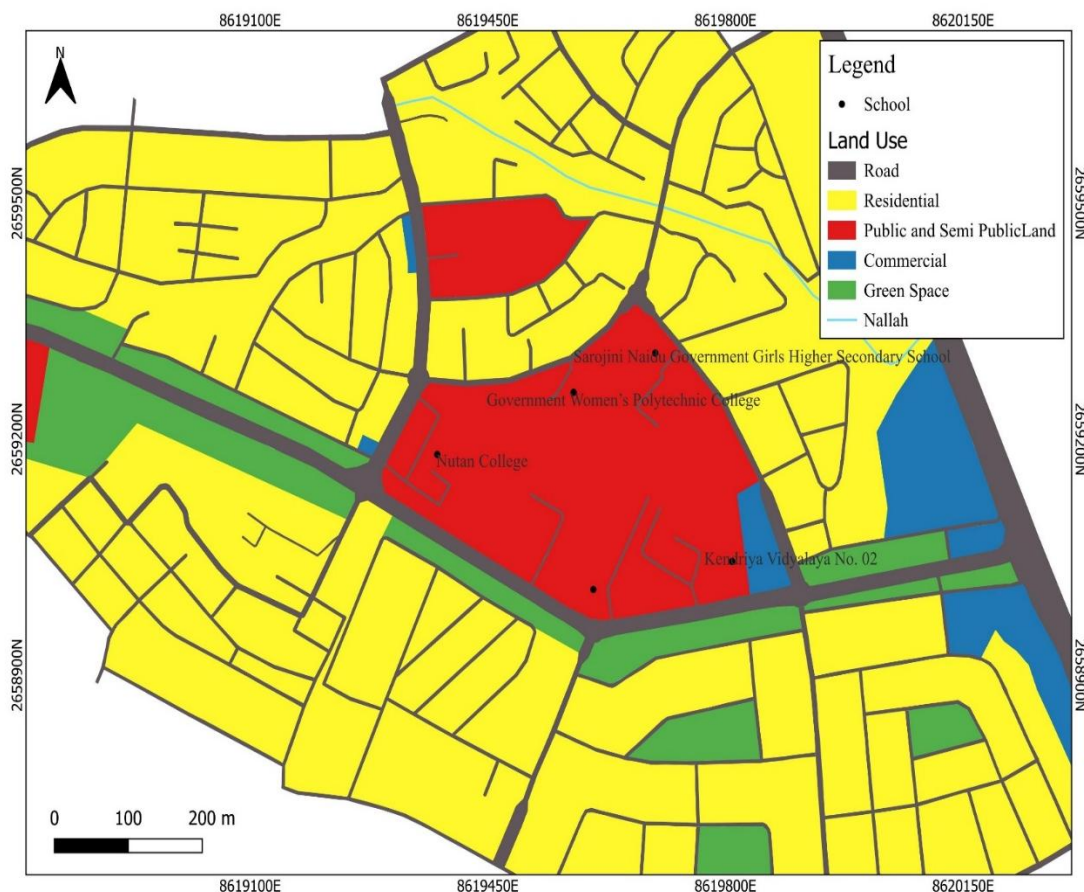


Fig. no. 2 Study Area Land Use Map

### 3.2.4 Relevance of the Study Area for School Zone Safety

The Shivaji Nagar institutional cluster represents a typical urban educational environment where multiple schools operate within a shared road network. Such areas require careful planning and management to ensure safe access for children and other vulnerable road users. The concentration of students, the diversity of commuting modes, and the existing infrastructure constraints make the study area an appropriate case for examining school zone safety conditions. Understanding the mobility patterns and safety challenges in this area can provide valuable insights for developing targeted interventions aligned with national guidelines for school zone planning and road safety.

## 3.3 Survey Sample Profile

### 3.3.1 Survey Questionnaire

A structured questionnaire was carefully developed with the specific aim of gathering insights from both students and teachers regarding their perceptions of road safety in the vicinity of the school premises. The primary objective of this survey is to understand how individuals regularly commute to and from the school experience and evaluate the safety conditions of the surrounding roads.

The questionnaire has been designed to capture a wide range of information. It begins by exploring the respondents' **mode of travel**—whether they walk, cycle, use public transport, or rely on private vehicles. It then delves into their **daily experiences of navigating the road environment**, including walking along the roadside, crossing busy intersections, and interacting with vehicular traffic.

In addition, the survey seeks to identify **specific safety concerns** that students and teachers encounter, such as inadequate pedestrian crossings, speeding vehicles, lack of traffic signals, or insufficient footpaths. Beyond documenting these challenges, the questionnaire also aims to capture the **perceptions and attitudes of the respondents toward the need for safety improvements**. This includes their views on whether current infrastructure is sufficient, and what measures they believe could enhance safety—such as better signage, stricter enforcement of traffic rules, or the introduction of designated pedestrian zones.

By systematically collecting this information, the questionnaire serves as a valuable tool to highlight the lived experiences of the school community. The findings will provide evidence-based insights that can inform planners, administrators, and policymakers in designing interventions that make the school environment safer, more accessible, and more conducive to learning without the constant worry of road-related risks.

### 3.3.2 Survey Methodology

The survey was conducted across all five educational institutes located within the defined study area. The methodology was designed to ensure maximum participation and reliable data collection from both students and teachers.

To achieve this, the questionnaires were **physically administered within each institute**, allowing respondents to engage directly with the survey process. This in-person approach ensured clarity of questions, encouraged active involvement, and facilitated accurate responses.

In addition to the physical distribution, a **digital mode of participation** was also adopted. A Google Form link was circulated through the respective school WhatsApp groups, thereby extending the reach of the survey to those who preferred or required online access. This dual approach—combining offline and online methods—helped in capturing a broader and more representative set of responses.

The methodology not only emphasized inclusivity but also ensured that the perceptions of road safety were documented comprehensively. To complement the data collected, **photographs were taken during the survey process**, providing visual insights into the participation and engagement of respondents. These images serve as qualitative evidence, reinforcing the authenticity and participatory nature of the study.

### 3.3.3 Response Collected

A total of 269 responses were collected from students of class 1 to 12, diploma and graduation and 60 responses were collected from teachers.

#### Survey Photographs



(a) Interaction with students of Sarajini Naidu School



(b) Interaction with students of Kendriya Vidyalaya No.2

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*(c) principal of Sarojini Naidu Government Girls School*



*(d) students of Sarojini Naidu Government Girls School*



*(e) Interaction with teachers of Subhash Excellence Government Higher Secondary School*



*(f) Interaction with students of Subhash Excellence Government  
Higher Secondary School*



*(g) Interaction with students at Government women's Polytechnic  
College*



*(h) Interaction with students and teachers of Nutan College*

Fig. No. 3 Survey Photographs

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Fig. No. 4 Survey Photographs with location

### 3.3.4 Data Analysis

The survey responses were processed through a multi-stage analytical framework to ensure both accuracy and interpretive depth. Initially, raw data was **cleaned and validated** to remove incomplete or inconsistent entries, thereby strengthening the reliability of subsequent findings. Once verified, the dataset was segmented according to respondent categories (students, teachers, parents) to allow for comparative analysis across stakeholder groups.

For **quantitative variables**, descriptive statistics such as **frequency distributions, percentages, and mean scores** were calculated. This helped in identifying dominant trends, such as the proportion of students walking to school versus those using motorized transport, or the percentage of respondents perceiving road crossings as unsafe. The use of **Likert scale mean values** provided a measurable index of attitudes toward safety measures, enabling the study to rank concerns in order of severity.

Beyond descriptive measures, **cross-tabulation techniques** were applied to explore relationships between variables. For instance, perceptions of safety were compared against travel mode, revealing that students commuting on foot expressed significantly higher concerns about traffic exposure compared to those arriving by bus or private vehicles. Such relational insights added depth to the interpretation of survey results.

For **qualitative responses**, thematic coding was employed. Recurring themes included:

- **Congestion at school gates** during peak hours.
- **Absence of designated pedestrian zones**, forcing children to share space with vehicles.
- **Limited awareness among drivers** regarding school zone regulations.

These themes were consolidated into categories that directly informed the problem diagnosis.

The integration of both quantitative and qualitative strands allowed the analysis to move beyond surface-level observations. It not only quantified perceptions but also contextualized them within the lived realities of the school community. This dual approach ensured that the findings were **evidence-based, multidimensional, and actionable**.

The outcomes of this analysis provided a **diagnostic foundation** for the proposal stage. By pinpointing specific deficiencies—such as inadequate pedestrian crossings, weak enforcement of speed limits, and lack of awareness campaigns—the study established a clear rationale for targeted interventions. These insights will guide the formulation of strategies that are **data-driven, context-sensitive, and aligned with international best practices in school zone safety**.

## SCHOOL ZONE SAFETY

The following section presents the **results of the data analysis**, focusing specifically on the responses obtained from students.

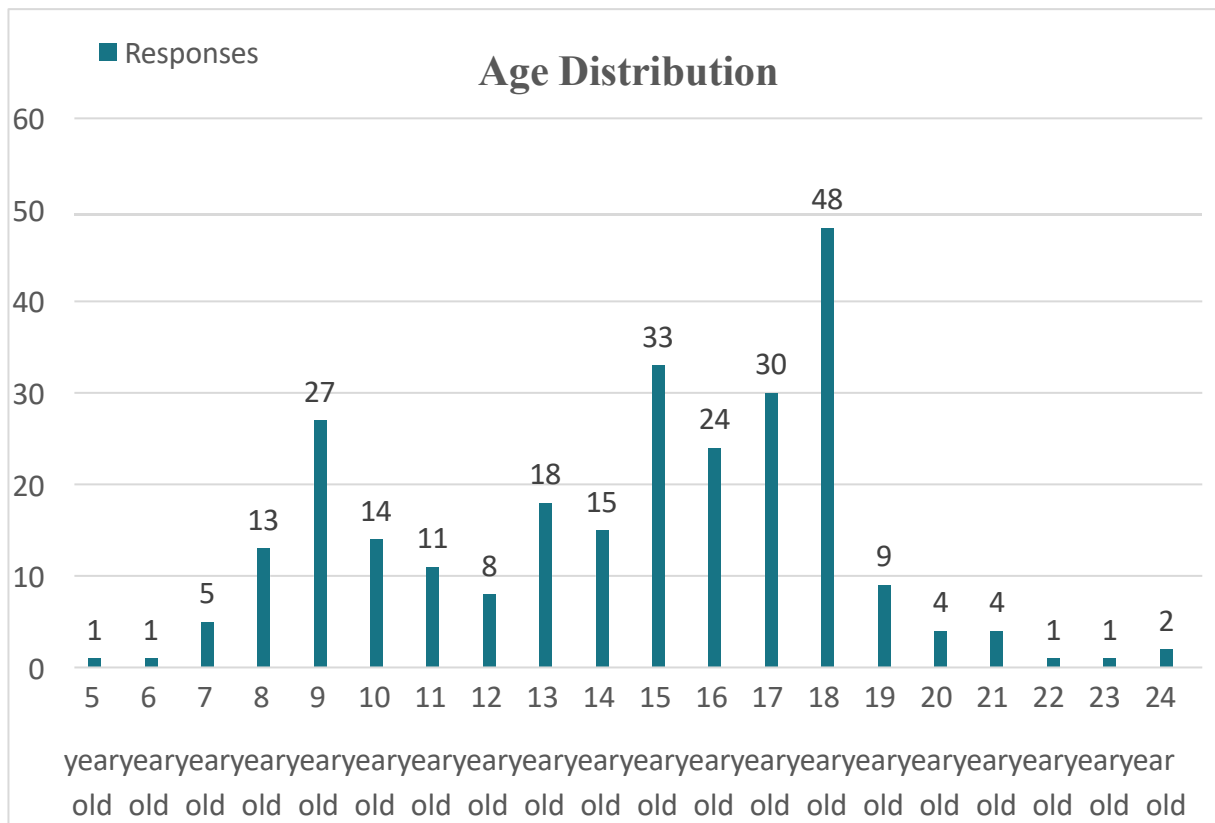


Fig. No. 5 Age Distribution

The age profile of respondents reveals a **distinct concentration in adolescence**, with participation peaking at age 18 (48 responses). This sharp clustering in the late teenage years underscores the relevance of high school students as the most actively engaged demographic in the survey. Their responses provide critical insights into the lived realities of those most exposed to daily school zone conditions.

A **secondary peak** is observed at age 9 (27 responses), representing younger school-going children. This early engagement highlights the vulnerability of primary school students, who often face challenges such as navigating crossings independently or relying on guardians for safe mobility. The contrast between this peak and the later surge in teenage years suggests that safety concerns span across age groups, but manifest differently—young children experience dependency-related risks, while adolescents face autonomy-related risks.

The **middle school years (10–14)** show fluctuating participation, indicating transitional mobility patterns. During this stage, students gradually shift from being escorted to school toward independent travel, which may explain the variability in responses. This transition

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period is crucial for identifying emerging safety challenges, such as increased exposure to traffic without adequate pedestrian infrastructure. The **sharp rise from ages 15 to 18** reflects the growing independence of older students, many of whom commute alone or in peer groups. Their heightened participation suggests stronger awareness and articulation of safety issues, including speeding vehicles, inadequate crossings, and congestion near school gates. This demographic is particularly valuable for policy recommendations, as they represent the group most capable of expressing nuanced concerns.

Post-18, the dataset shows a **steep decline in participation**, with single-digit responses across ages 19–24. This drop-off indicates that once students leave school, their direct engagement with school zone safety diminishes significantly. However, their limited input still provides perspective on residual concerns faced during late adolescence and early adulthood.

Overall, the distribution highlights three critical insights:

- **Primary school children (ages 5–9):** Vulnerable, dependent, and underrepresented in terms of voice.
- **Middle school students (ages 10–14):** Transitional, with fluctuating exposure and evolving independence.
- **High school adolescents (ages 15–18):** Dominant contributors, most vocal, and most directly impacted by unsafe conditions.

This pattern emphasizes that **school zone interventions must be age-sensitive**, addressing the distinct needs of younger children (safe crossings, escorts), transitional students (infrastructure for semi-independent travel), and older adolescents (traffic calming, enforcement, and awareness programs). By tailoring measures to these age clusters, planners can ensure a holistic approach that safeguards all segments of the school community.

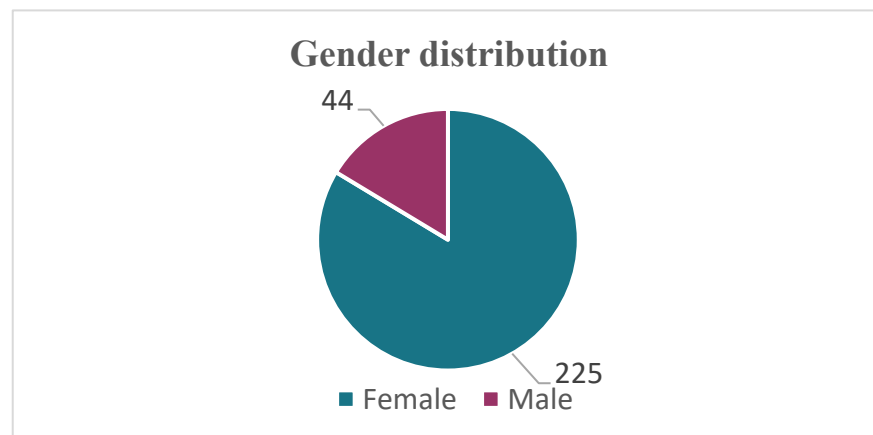


Fig. No. 7 Gender Distribution

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The analysis of gender distribution among respondents reveals a pronounced imbalance, with females accounting for 225 responses (84%) and males contributing only 44 responses (16%). This substantial skew indicates that the dataset is heavily dominated by female perspectives, which has important implications for both the interpretation of findings and the formulation of planning recommendations. Such a distribution may reflect the actual demographic composition of the surveyed population—particularly in the context of school environments where female teachers, caregivers, or guardians are often more actively involved in children’s daily mobility and safety concerns. Alternatively, it may also indicate a higher level of willingness or engagement among female respondents in participating in surveys related to child safety and community well-being.

This dominance of female responses is significant because gender can influence perception, experience, and sensitivity toward safety issues. Women, especially those responsible for accompanying children, may be more aware of risks such as unsafe crossings, speeding vehicles, lack of pedestrian infrastructure, and chaotic traffic conditions near school gates. As a result, the findings derived from the survey are likely to emphasize concerns related to personal security, accessibility, and the need for protective infrastructure. This perspective is valuable and aligns with the broader objective of creating child-friendly and inclusive environments; however, it may not fully capture the experiences and perceptions of male respondents, who might interact differently with the same environment.

The imbalance also raises considerations regarding representativeness and potential bias in the dataset. While the strong female participation enhances the depth of insight into safety-related concerns, the relatively low proportion of male respondents suggests that their viewpoints are underrepresented. This could influence the overall assessment of travel behavior, risk perception, and preferred interventions. Therefore, while the findings remain valid and meaningful, they should be interpreted with an understanding that they reflect a gender-skewed sample.

From a planning perspective, this distribution reinforces the importance of adopting gender-sensitive approaches in school zone design and policy formulation. It highlights the need to prioritize safety, visibility, accessibility, and comfort—factors that are often emphasized more strongly in female perceptions of urban space. At the same time, future studies and interventions should aim for a more balanced gender representation to ensure a holistic understanding of user needs. Ensuring inclusive participation across genders will lead to more comprehensive and equitable planning outcomes, ultimately benefiting all users of the school zone environment.

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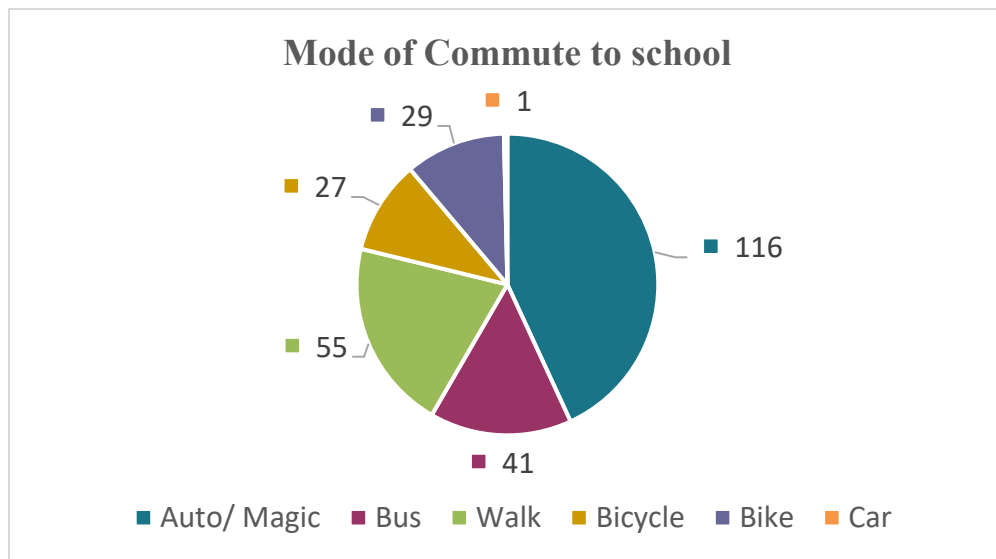


Figure 8. Mode of commute to school

The data on commuting modes reveals that the majority of students travel to school by **Auto/Magic**, accounting for 116 responses (46.4%). This heavy reliance on shared para-transit options reflects both affordability and accessibility, but it also raises concerns about overcrowding, lack of regulation, and inconsistent safety standards. Given its dominance, any school zone intervention must directly address the operational practices and safety of auto-rickshaws and similar shared vehicles.

**Walking** emerges as the second most common mode, with 55 students (22%). This significant share underscores the importance of pedestrian infrastructure, as a large proportion of children navigate congested and unsafe road environments daily. Safe sidewalks, zebra crossings, and traffic calming measures are therefore critical to protect this vulnerable group.

**Bus travel** accounts for 41 responses (16.4%), representing a more formalized and relatively safer commuting option. However, its lower share compared to autos suggests limited coverage or accessibility of school bus services. Expanding bus networks could reduce dependence on informal transport and enhance overall safety.

Smaller proportions of students commute by **bicycle (27, 10.8%)** and **bike (29, 11.6%)**. Bicycles promote sustainable mobility but expose students to risks in traffic-heavy environments due to the absence of cycling lanes. Motorbike usage, particularly among adolescents, raises concerns about licensing, speed, and protective gear, pointing to regulatory gaps in enforcement.

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Finally, **car usage is negligible**, with only 1 student (0.4%) reporting this mode. This minimal share highlights socioeconomic realities and limited access to private vehicles, reinforcing the need for collective, community-oriented solutions rather than individual interventions.

### Key Insights

- **Dominant reliance on Auto/Magic (46.4%)** → urgent need for regulation and designated stands.
- **High pedestrian share (22%)** → priority for sidewalks, crossings, and traffic calming.
- **Moderate bus usage (16.4%)** → scope for expansion to reduce informal transport dependence.
- **Bicycle and bike commuters (~22%)** → infrastructure and enforcement gaps for safe independent travel.
- **Negligible car usage (0.4%)** → interventions must focus on shared and public modes, not private vehicles.

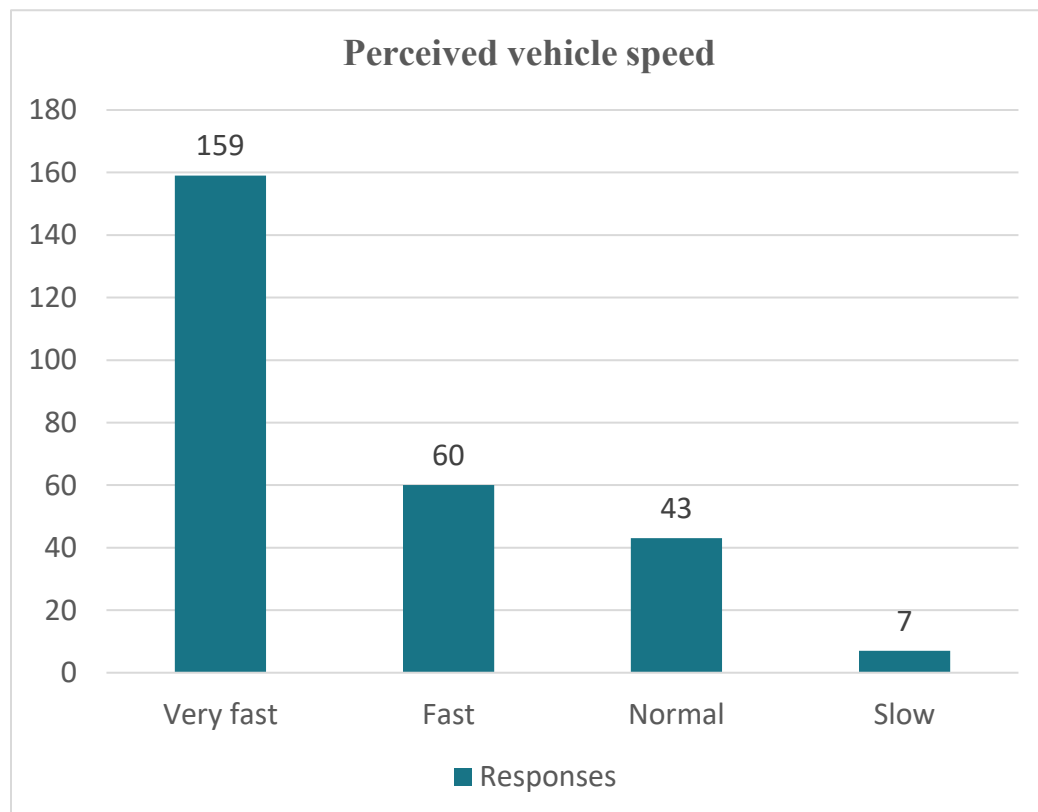


Fig. No. 9. Perceived vehicle speed

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The analysis of perceived vehicle speed reveals a striking imbalance in how respondents experience traffic conditions around the school zone. A substantial majority, comprising **159 individuals (61.6%)**, categorized vehicle movement as “*Very fast*,” while an additional **60 respondents (23.3%)** described it as “*Fast*.” In contrast, only **43 respondents (16.6%)** considered speeds to be “*Normal*,” and a negligible **7 respondents (2.7%)** perceived them as “*Slow*.” This overwhelming skew toward higher speed categories indicates that road users, particularly students and staff, consistently encounter traffic environments that feel unsafe and uncontrolled. The dominance of “*Very fast*” responses underscores the inadequacy of current speed regulation and enforcement mechanisms, pointing to systemic gaps in traffic management within school zones. Such perceptions are not merely subjective impressions but reflect lived experiences of vulnerable groups navigating crossings, sidewalks, and entry points under conditions of high-speed vehicular movement. The findings highlight the urgent need for comprehensive speed management interventions, including stricter enforcement of speed limits through monitoring and penalties, installation of traffic calming infrastructure such as raised crosswalks, rumble strips, and speed humps, and awareness campaigns to sensitize drivers about the risks of speeding near schools. Addressing these concerns is essential to align traffic behavior with the protective requirements of school zones and to ensure a safer commuting environment for children.

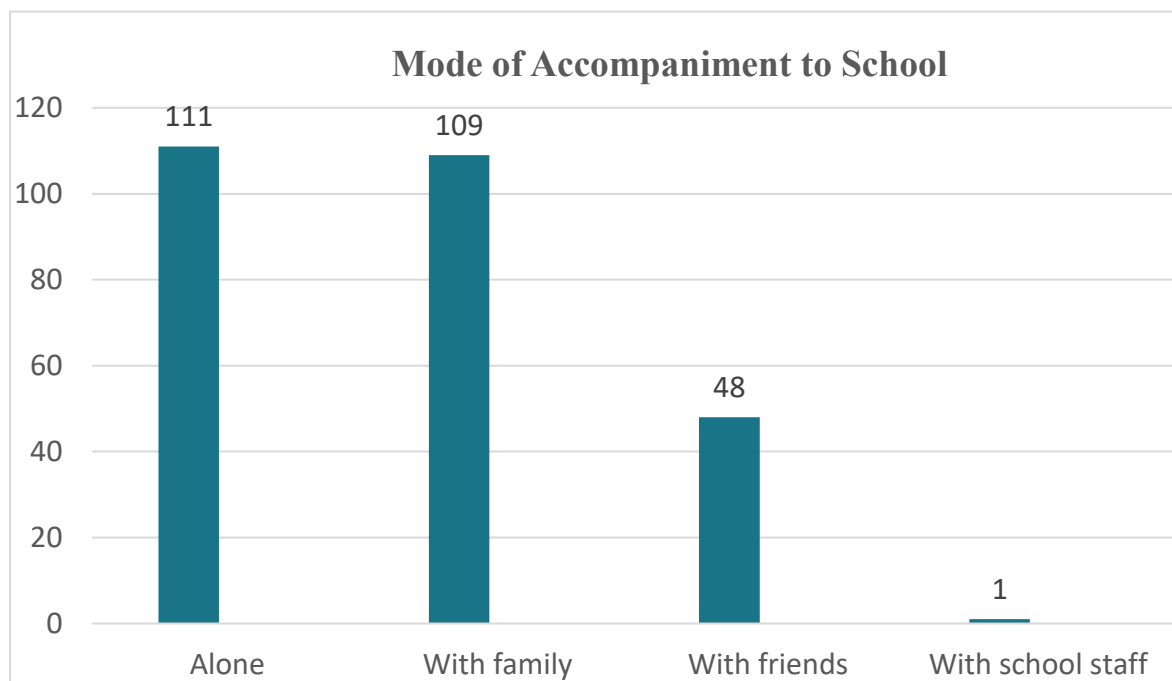


Fig. No. 10 Mode of Accompaniment to School

## SCHOOL ZONE SAFETY

The data on accompaniment to school reveals a clear pattern in students' travel behavior, with the majority relying either on independent travel or family support. A total of 111 students (38.9%) reported traveling alone, while 109 students (38.2%) commute with family members. Together, these two categories account for a dominant share of responses, indicating that most school trips are either self-managed by students or facilitated within the household. In contrast, a smaller proportion of students (48, 16.8%) travel with friends, and accompaniment by school staff is almost negligible, with only 1 response (0.4%).

This distribution highlights a significant absence of structured or institutional support systems for student mobility. The extremely low involvement of school staff in accompanying students suggests that formal mechanisms such as supervised transport, escort systems, or organized walking groups are either unavailable or not widely utilized. As a result, the responsibility for ensuring safe travel largely falls on individual students and their families, rather than being supported by coordinated school-level or community-based initiatives.

The high proportion of students traveling alone is particularly important from a safety perspective. It indicates that a substantial number of children are independently navigating traffic conditions, road crossings, and potentially unsafe environments on a daily basis. This increases their exposure to risks, especially in areas where pedestrian infrastructure is inadequate, traffic speeds are high, and crossings are unregulated. Consequently, it reinforces the urgent need for well-designed pedestrian infrastructure, traffic calming measures, and clearly marked crossings to ensure that children can travel safely without adult supervision.

At the same time, the nearly equal share of students commuting with family members reflects a strong dependence on household-based travel arrangements. This may include walking with parents, being dropped off by two-wheelers or cars, or using informal transport modes arranged by families. While this can provide a degree of safety and supervision, it also contributes to congestion and chaotic conditions near school gates, particularly during peak hours. The reliance on family-based commuting further indicates the absence of efficient, safe, and reliable school transport systems or community-supported travel options.

The relatively smaller proportion of students traveling with friends suggests that peer-based mobility exists but is not a dominant mode. This could be due to safety concerns, lack of organized group travel systems, or varying travel routes and timings among students. Encouraging group-based travel, such as supervised walking groups or "walking school bus" initiatives, could help bridge this gap by combining safety with social interaction.

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Overall, the findings emphasize the need to strengthen both infrastructure and institutional mechanisms to support safer and more organized school travel. Enhancing pedestrian safety, introducing supervised travel programs, and reducing dependence on individual or family-based arrangements can contribute to a more secure and efficient school zone environment.

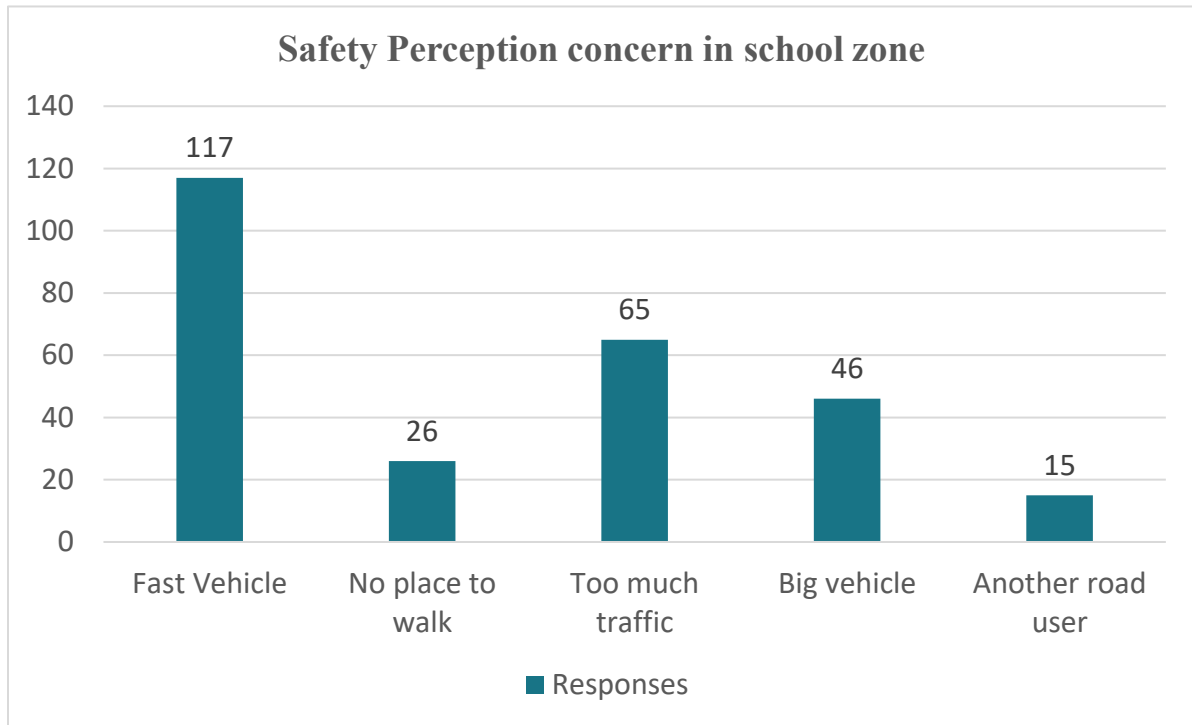


Fig. No 11 Safety Perception concern in school zone

The analysis of safety concerns reported by respondents reveals that fast-moving vehicles are overwhelmingly perceived as the most critical risk, with **117 responses (47.6%)** identifying speed as the dominant issue. This finding aligns with broader perceptions of unsafe traffic conditions and underscores the inadequacy of current enforcement and calming measures in school environments. The second most cited concern is **traffic volume**, highlighted by **65 respondents (26.4%)**, which reflects the challenges posed by congestion during peak school hours and the heightened exposure of children to chaotic vehicular flows. The presence of **large vehicles**, such as buses and trucks, was noted by **46 respondents (18.7%)**, indicating apprehension about the dangers of heavy traffic mixing with vulnerable pedestrians in narrow or poorly designed road spaces. A smaller but significant proportion of participants emphasized the **lack of pedestrian space (26 responses, 10.6%)**, pointing to infrastructural deficiencies such as absent sidewalks, encroachments, or inadequate crossings. Finally, **other road users (15 responses, 6.1%)** were identified as a concern, reflecting issues of driver behavior, non-compliance with

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traffic rules, and unsafe practices by motorcyclists or informal transport operators. Collectively, this distribution highlights that speed and traffic intensity dominate safety perceptions, making them the most urgent priorities for intervention. At the same time, secondary concerns related to pedestrian infrastructure and large vehicles emphasize the need for a holistic approach to school zone safety—one that integrates stricter speed management, traffic calming strategies, congestion control, regulated access for heavy vehicles, and the creation of child-friendly walking facilities. Such measures would not only address the immediate risks identified by the majority but also ensure long-term improvements in accessibility, inclusivity, and safety for the entire school community.

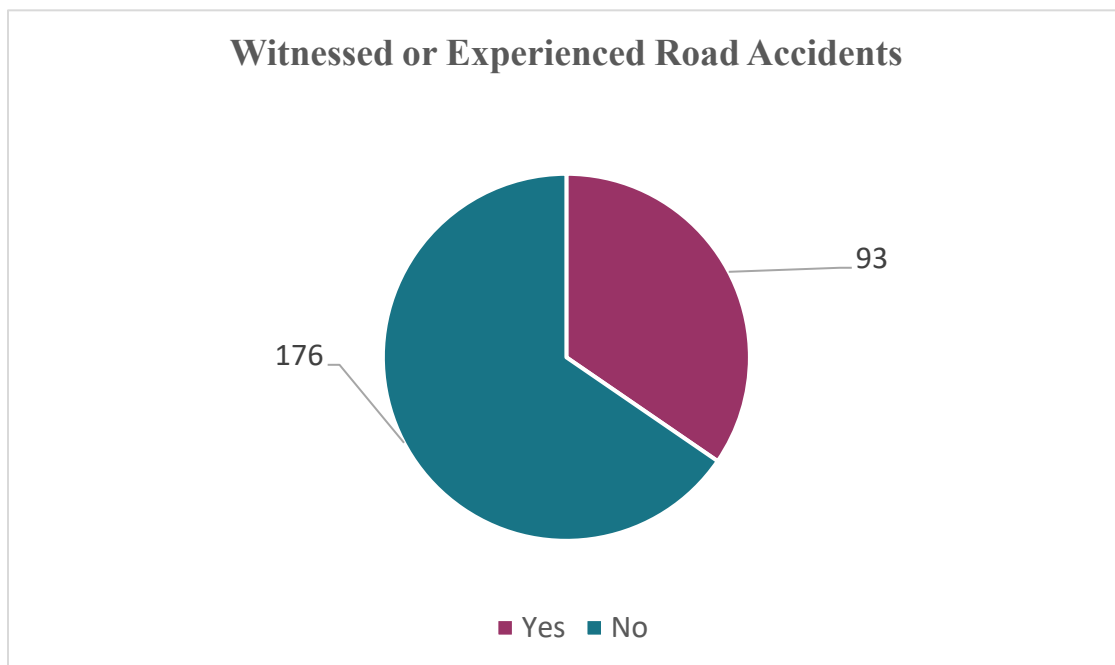
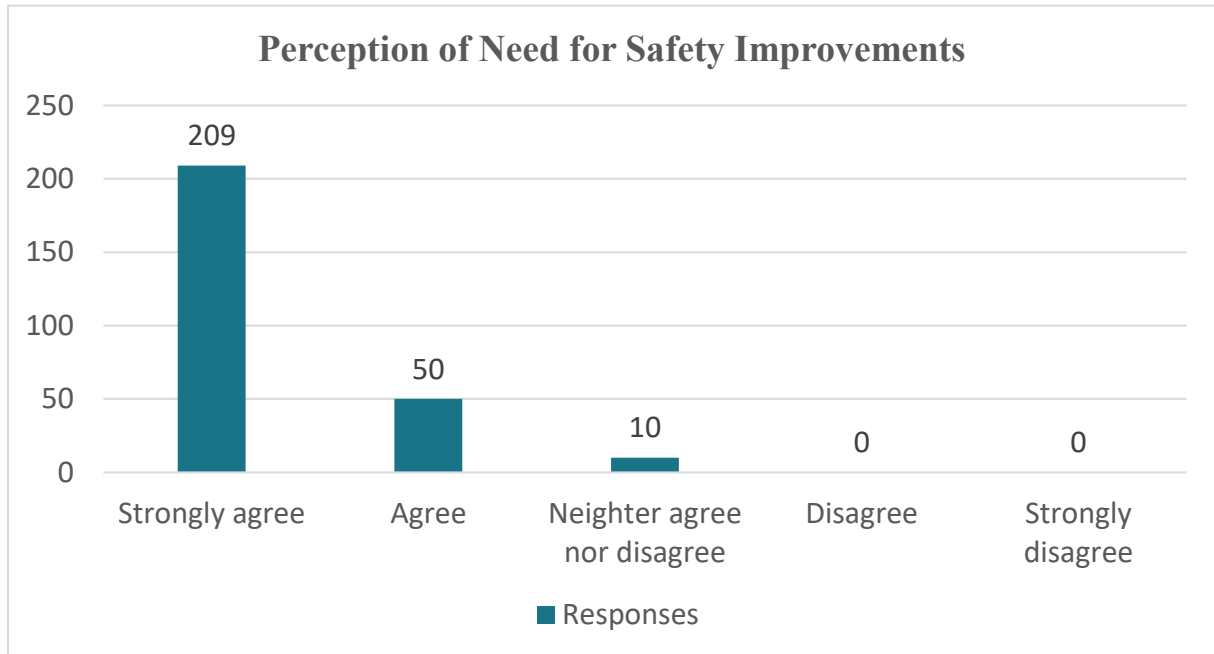


Fig. No. 12 Witnessed or Experienced Road Accidents

The data on road accident experiences indicates a mixed pattern of exposure among respondents, with a majority of 176 individuals (65.4%) reporting that they have not witnessed or experienced any accidents. This suggests that for a larger section of participants, direct interaction with road accidents remains limited. However, a significant proportion of respondents—93 individuals (34.6%)—stated that they have encountered accidents, which accounts for more than one-third of the total sample. This is a considerable share and indicates that road safety risks are not isolated but fairly prevalent within the study area. Even if not everyone has direct experience, the presence of such exposure reflects underlying unsafe traffic conditions, particularly around school zones. It also suggests that certain groups, such as students traveling independently or navigating inadequate infrastructure, may be more vulnerable to such risks. Furthermore, the data may also hint at possible underreporting or normalization of minor incidents that are not always

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formally acknowledged. Overall, while the majority has not directly experienced accidents, the fact that a substantial proportion has encountered them highlights the need for proactive



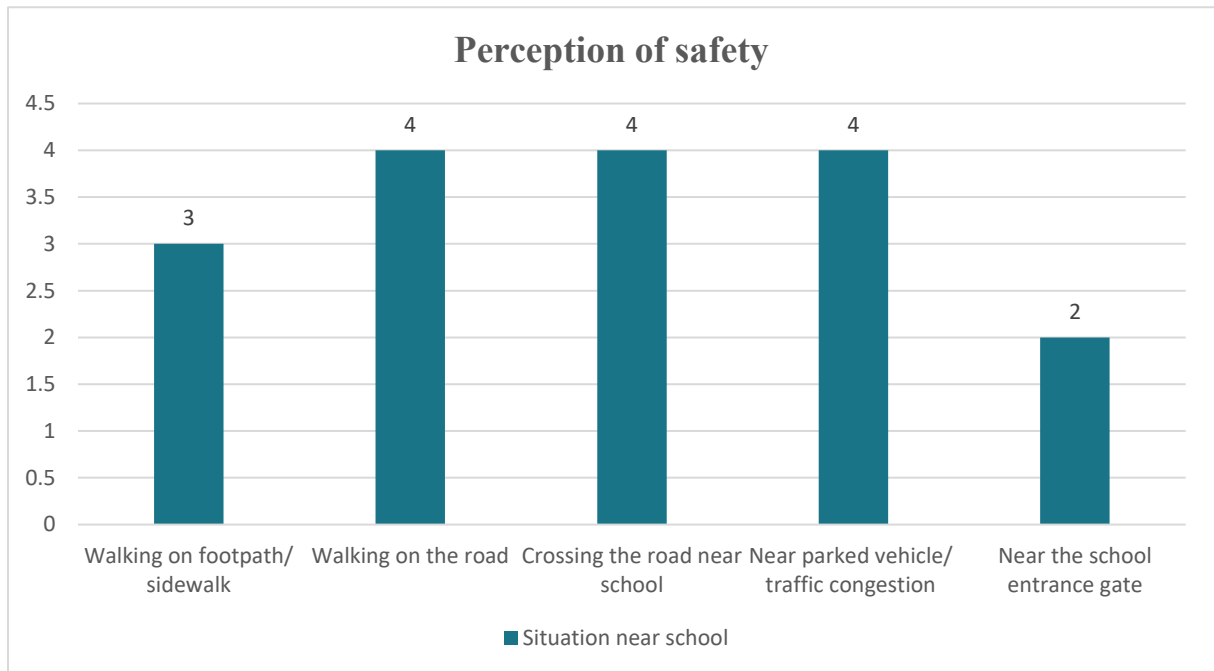
and preventive safety interventions. This reinforces the importance of improving infrastructure, regulating traffic behavior, and ensuring safer environments to minimize risks for all road users, especially children.

Fig. No. 13 Perception of Need for Safety Improvements

The survey results reveal an overwhelming consensus regarding the need for safety improvements in school zones. A significant majority of respondents, 209 individuals (77.6%), strongly agree that such measures are necessary, while an additional 50 respondents (18.6%) also agree, collectively accounting for nearly the entire sample. Only a very small proportion, 10 respondents (3.7%), expressed a neutral stance, and notably, there were no responses indicating disagreement or strong disagreement. This distribution clearly reflects a unified perception among stakeholders about the presence of safety concerns and the urgent need to address them. The absence of negative responses further strengthens the reliability of this consensus, suggesting that safety issues are widely recognized and experienced across different user groups. Such strong agreement not only highlights awareness but also indicates a high level of public support for implementing corrective measures. This provides a clear and compelling mandate for policymakers and planners to take immediate action through comprehensive interventions, including improvements in infrastructure, stricter enforcement of traffic regulations, and enhanced safety awareness initiatives. Ultimately, the findings emphasize that creating safer, more

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secure, and child-friendly school environments is not just a planning requirement but a collectively acknowledged priority.



Safety levels (1= Very safe, 2= Safe, 3= Neither Safe nor unsafe, 4= Unsafe, 5= Very unsafe)

Fig No. 14 Perception of Safety

The perception of safety in different school-related walking situations reveals notable variations, reflecting the diverse risks encountered by students and staff in their daily commute. Respondents rated **walking on the road, crossing near the school, and being near parked vehicles or traffic congestion** as relatively unsafe, each with a score of **4** on the perception scale. These contexts highlight the vulnerability of pedestrians when exposed directly to vehicular movement, particularly in areas lacking adequate infrastructure or traffic regulation. **Walking on a footpath or sidewalk** was perceived as moderately safe, with a score of **3**, suggesting that while designated pedestrian pathways provide some protection, they may be insufficient in terms of continuity, width, or maintenance. The **school entrance gate**, however, emerged as the most critical point of concern, with the lowest safety score of **2**, indicating that congestion, vehicle movement, and inadequate pedestrian management at entry points create heightened risks. This distribution underscores that traffic-related contexts are consistently viewed as unsafe, but

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the entrance gate stands out as a focal area requiring immediate intervention. The findings emphasize the need for targeted safety measures at school entry points, including regulated pick-up and drop-off zones, improved pedestrian circulation, and strict enforcement of speed and parking rules. At the same time, broader improvements in pedestrian infrastructure and traffic calming strategies are essential to ensure safer mobility across all school-related environments.

**The following section presents the results of the data analysis obtained from the survey of teachers.**

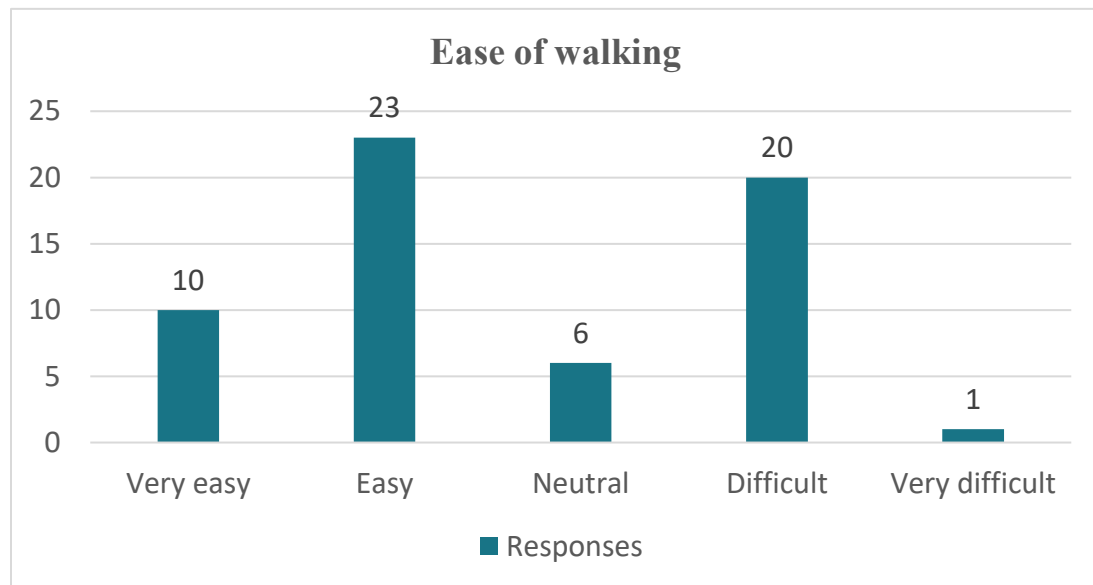


Fig. No. 15 Ease of walking

The perception of walking ease among respondents presents a varied and somewhat polarized pattern, reflecting both positive and challenging experiences within the school zone environment. A majority of participants reported favorable conditions, with 23 respondents (38.3%) describing walking as “Easy” and an additional 10 respondents (16.7%) as “Very easy,” together accounting for more than half of the total responses. This indicates that for a considerable portion of users, walking is relatively manageable and does not pose significant difficulty. However, this positive trend is counterbalanced by a notable proportion of respondents who experience challenges while walking. Specifically, 20 individuals (33.3%) rated walking conditions as “Difficult,” and 1 respondent (1.7%) as “Very difficult,” highlighting that nearly one-third of the participants face discomfort or barriers in pedestrian movement. Additionally, 6 respondents (10%) expressed a neutral perception, suggesting variability in experiences depending on specific routes, timings, or conditions.

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This distribution underscores that while walking may be feasible for many, it is not consistently safe or comfortable for all users. The presence of a substantial share of respondents reporting difficulty points to underlying issues such as inadequate or discontinuous footpaths, encroachments, unsafe crossings, and conflicts with vehicular traffic. These challenges can disproportionately affect younger students, who are more vulnerable and less capable of navigating unsafe environments independently. Therefore, the findings highlight the urgent need to improve pedestrian infrastructure and ensure inclusive, accessible, and safe walking conditions. Addressing these gaps is essential not only to enhance daily commuting experiences but also to promote walking as a safe and viable mode of travel within school zones.

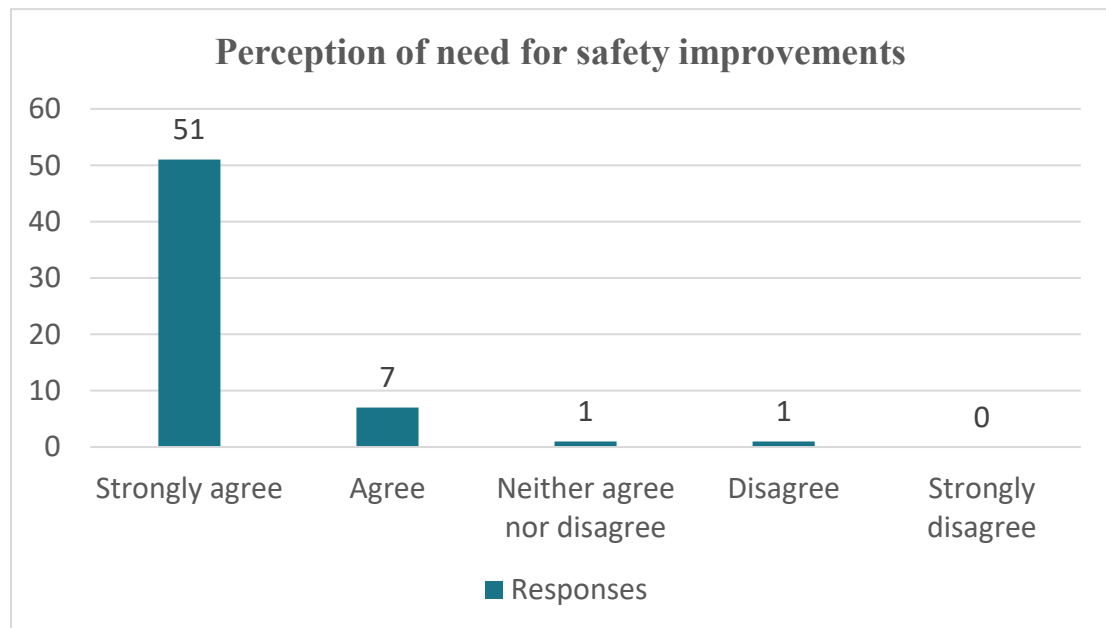


Fig. No. 16 Perception of need for safety improvements

The survey results indicate a strong consensus on the need for safety improvements in school zones. A majority of respondents, 51 (85%), strongly agree with the necessity of such measures, while an additional 7 (11.7%) agree. Only 1 respondent (1.7%) expressed neutrality, and another 1 (1.7%) disagreed, with none strongly disagreeing. This distribution highlights overwhelming support for safety interventions, reflecting widespread recognition of risks and a collective demand for action. The findings provide a clear mandate for implementing targeted strategies such as infrastructure upgrades, stricter traffic regulation, and awareness initiatives to ensure safer and more child-friendly school environments.

### **Key Findings**

The analysis of responses obtained from **269 students and 60 teachers** provides clear insights into the current road safety conditions around the selected educational institutes. The results highlight the presence of major safety concerns and the urgent need for structured school zone interventions.

#### **1. Vulnerable User Group**

The majority of respondents belong to younger age groups, particularly adolescents aged 15–18, who are highly exposed to daily traffic risks. A significantly higher proportion of female respondents (84%) emphasizes the importance of gender-sensitive safety planning, as their perspectives dominate the dataset.

#### **2. Dependence on Informal and Active Modes**

A large share of students rely on informal transport modes such as Auto/Magic, contributing to congestion during peak school hours. At the same time, many students walk or cycle despite inadequate infrastructure, exposing them to traffic conflicts and unsafe conditions. The negligible use of private cars highlights reliance on shared and active modes.

#### **3. High Vehicle Speeds Near School Areas**

Most respondents perceive vehicle speeds near schools as “very fast” or “fast,” indicating the absence of effective speed control measures. Overspeeding emerges as a major safety concern, directly linked to students’ fear and accident exposure.

#### **4. Independent Travel of Students**

A considerable proportion of students commute independently, often without adult supervision. The lack of continuous footpaths, safe crossings, and pedestrian-friendly infrastructure increases their vulnerability to unsafe traffic conditions.

#### **5. Fear of Fast-Moving Traffic and Heavy Congestion**

Students expressed strong concerns about fast-moving vehicles and traffic congestion. The absence of safe pedestrian facilities, coupled with overspeeding, contributes significantly to this perception of unsafety. Heavy traffic and large vehicles further intensify the risks around school zones.

#### **6. Exposure to Accident Situations**

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Over one-third of respondents reported witnessing or experiencing road accidents near school areas. Many of these incidents involved two-wheelers, highlighting conflict-prone conditions and the urgent need for traffic calming and enforcement measures.

### **7. Unsafe Road Crossing and Walking Conditions**

Higher levels of perceived unsafety were associated with walking on roads without footpaths, crossing near schools, and navigating areas affected by on-street parking and congestion. While the school gate area showed relatively better safety perception, unsafe conditions remain across surrounding road segments.

### **8. Professional Consensus from Teachers**

Teachers reported similar difficulties in walking near school areas and strongly agreed on the need for improvements to be made. Their alignment with student concerns reflects a consistent perception across different user groups, strengthening the case for intervention.

### **9. Strong Demand for Safety Improvements**

Both students and teachers expressed overwhelming agreement on the need for structured school zone measures. The near-universal consensus provides a clear mandate for implementing safety interventions, ranging from infrastructure upgrades to stricter traffic regulation and awareness campaigns.

## **3.4 Four E Planning Problem Framework — Identified Deficiencies**

The application of the 4E Planning Framework—Engineering, Enforcement, Education, and Encouragement—offers a comprehensive lens to interpret the observed conditions and survey findings across the five selected school zones. The analysis reveals that safety challenges are not isolated but systemic, arising from interlinked deficiencies across all four pillars. These gaps contribute to an unsafe and unregulated environment for children, particularly during peak school hours.

From an engineering perspective, the physical environment surrounding the schools is inadequate and fails to meet even the minimum safety standards prescribed for school zones. Essential traffic calming measures such as raised pedestrian crossings, table-top crosswalks, zebra markings, and rumble strips are entirely absent, exposing children to high-speed vehicular movement without any protective intervention. Pedestrian infrastructure is either missing, discontinuous, or encroached upon within the 300-meter influence zone, forcing students to walk along the carriageway and directly interact with moving traffic. Furthermore, the lack of designated pick-up and drop-off bays at school gates leads to chaotic parking and unsafe on-road stopping, significantly increasing congestion and risk. The absence of protective elements such as bollards, guardrails, kerb

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extensions, and channelization further exacerbates the vulnerability of school frontages, indicating a clear neglect of child-centric street design.

In terms of enforcement, there is a near-total absence of regulatory oversight and traffic management. Although a school zone speed limit of 25 kmph is mandated, it is neither implemented nor communicated through appropriate signage or enforcement mechanisms. The absence of traffic police personnel during critical arrival and dispersal hours results in unmanaged crossings and disorderly vehicular movement near school gates. Additionally, there is no provision for CCTV surveillance or electronic monitoring systems, which significantly reduces accountability and compliance among road users. Encroachments in the form of on-street parking, informal vendors, and blocked footpaths remain unchecked, further constricting space and increasing pedestrian risk. A notable gap is the lack of coordination among key stakeholders, including municipal authorities, traffic police, Public Works Department (PWD), and school administrations, which leads to fragmented and ineffective governance of school zone safety.

The education component of the framework highlights a critical deficiency in awareness-building and behavioral guidance among all user groups. None of the surveyed schools have implemented structured road safety education programs, leaving students without the necessary knowledge and skills to navigate traffic environments safely. The absence of crossing guards, safety wardens, or patrol systems further limits on-ground guidance and supervision, particularly for younger children. Parents are also not provided with any formal instructions or guidelines regarding safe drop-off practices, staggered timings, or designated zones, which contributes to disorder and congestion. Survey findings indicate that younger students, especially those in Classes 1 to 4, possess below-average awareness of road safety practices despite being the most vulnerable group. Moreover, there is no evidence of community engagement initiatives such as parent volunteer programs, safety clubs, or local vigilance networks, resulting in a lack of shared responsibility and collective action toward improving safety conditions.

The encouragement dimension reflects a complete absence of initiatives aimed at promoting safe, active, and sustainable modes of travel. There is no supporting infrastructure for non-motorized transport, such as dedicated cycle lanes or safe pedestrian corridors, connecting residential areas to schools. The overall streetscape is hostile and uninviting, lacking basic elements such as shading, buffers from traffic, and pedestrian-friendly design features that could encourage walking. Programs like the “Walking School Bus” or supervised group walking initiatives are not present, limiting opportunities for safer and more organized active travel. At the planning level, there is no visible integration of non-motorized transport or active mobility goals within municipal road development strategies, reflecting a broader policy gap and lack of prioritization for child-friendly mobility.

In conclusion, the deficiencies identified across all four components of the 4E framework point toward a systemic and deeply embedded failure in ensuring school zone safety. The absence of adequate engineering measures exposes children to direct traffic hazards, while weak enforcement allows unsafe practices to continue without consequence. Simultaneously, the lack of education leaves both children and caregivers ill-equipped to respond to risks, and the absence of encouragement mechanisms discourages the adoption of safer and healthier commuting alternatives. These interconnected shortcomings create a hostile and high-risk environment for students, necessitating urgent, coordinated, and multi-dimensional interventions that integrate infrastructure improvement, regulatory enforcement, behavioral education, and policy-level support for sustainable mobility.

### 3.5 Conclusion

This study has provided a comprehensive assessment of school zone safety within the Shivaji Nagar institutional cluster in Bhopal by integrating survey data, field observations, and spatial analysis. The results demonstrate that the existing school zone environment is marked by critical safety deficiencies, particularly in pedestrian infrastructure, traffic regulation, and the management of mobility during peak school hours. Children, as the most vulnerable group of road users, are routinely exposed to unsafe conditions due to high vehicular speeds, inadequate crossing facilities, and unregulated traffic movement near school premises.

The analysis highlights that many students depend on informal transport modes such as auto-rickshaws, while a considerable number walk or travel independently without adequate infrastructural support. Perceptions of fast-moving traffic, unsafe crossings, and congestion contribute to a heightened sense of insecurity among both students and teachers. The fact that a significant proportion of respondents reported witnessing or experiencing road accidents further reinforces the urgency of intervention. Importantly, the strong consensus among stakeholders regarding the need for safety improvements provides a clear mandate for immediate action.

The application of the **4E Planning Framework—Engineering, Enforcement, Education, and Encouragement—enabled systematic identification of gaps across multiple dimensions.** The absence of traffic calming measures, discontinuous pedestrian pathways, weak enforcement of speed limits, lack of structured awareness programs, and minimal promotion of non-motorized transport collectively contribute to a hostile and high-risk environment. These interconnected issues require a holistic and integrated approach to achieve meaningful improvements.

In response, the study proposes a set of **context-specific planning interventions** aligned with the guidelines of the Indian Roads Congress. These include speed management strategies, continuous and accessible pedestrian infrastructure, clear delineation of school zones, strengthened enforcement mechanisms, and awareness initiatives involving parents,

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teachers, and students. The integration of environmental sustainability and promotion of non-motorized transport further enhances the inclusiveness and long-term viability of the proposed framework. A phased implementation strategy ensures that immediate, low-cost measures such as signage and enforcement can be introduced quickly, while long-term interventions focus on infrastructure upgrades, behavioral change, and community participation.

Ultimately, this study underscores that school zone safety is not merely an infrastructural challenge but a **multi-dimensional planning issue** requiring coordinated efforts from government agencies, educational institutions, and the community. The findings and proposals presented here offer a replicable model for improving school zone safety in Bhopal and similar urban contexts. By prioritizing the needs of children and adopting a comprehensive planning approach, it is possible to create safer, more inclusive, and resilient urban environments that support both mobility and well-being.

## CHAPTER 4

### PLANNING PROPOSALS AND STRATEGIES

This chapter presents the comprehensive planning proposals for improving school zone safety in the Shivaji Nagar institutional cluster, Bhopal. The proposals are structured around four research objectives, each directly responding to the deficiencies identified in the field analysis and stakeholder surveys of Chapter 3. All interventions are benchmarked against Indian Roads Congress (IRC) guidelines — principally IRC: SP:32-2023 (Road Safety for Children), IRC:99-2018 (Traffic Calming), IRC:103-2012 (Pedestrian Facilities), IRC:35-2015 (Road Markings), and IRC:67-2012 (Road Signs). The chapter is organized into an introduction, a statement of objectives, four proposal sections (one per objective), an implementation plan, a governance and financing framework, and a monitoring framework. Large technical specification tables that support the proposals are consolidated in Appendix B.

**Table 4.1:** Chapter Structure and Objective–Proposal Linkage

| Section | Heading                                     | Linked Objective | Core Content                                                                                    |
|---------|---------------------------------------------|------------------|-------------------------------------------------------------------------------------------------|
| 4.1     | Introduction                                | All              | Context, survey evidence, chapter guide                                                         |
| 4.2     | Research Objectives                         | All              | Four thesis-style objectives, problem linkage                                                   |
| 4.3     | Speed Management and Traffic Calming        | Objective 4.2.1  | Raised crossings, speed humps, gateway treatments, raised junction, LPI signal                  |
| 4.4     | Pedestrian and Non-Motorized Infrastructure | Objective 4.2.2  | Footpaths, kerb ramps, guard rails, medians, safe walking routes, cycling corridor, WSB         |
| 4.5     | School Zone Delineation and Enforcement     | Objective 4.2.3  | Signage package, pavement markings, TROs, CCTV network, Police deployment, Warden programme     |
| 4.6     | Inclusive and Sustainable Approaches        | Objective 4.2.4  | Staggered timings, green buffers, climate design, road safety education, RSC, parent engagement |
| 4.7     | Implementation Plan                         | All              | Three-phase timeline, costs, financing sources                                                  |

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|                   |                                |     |                                                                        |
|-------------------|--------------------------------|-----|------------------------------------------------------------------------|
| <b>4.8</b>        | Governance and Monitoring      | All | SZSC composition, KPIs, replication framework                          |
| <b>Appendix A</b> | Technical Specification Tables | All | Detailed IRC-parameter specification tables for each intervention type |

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### Existing Drawings

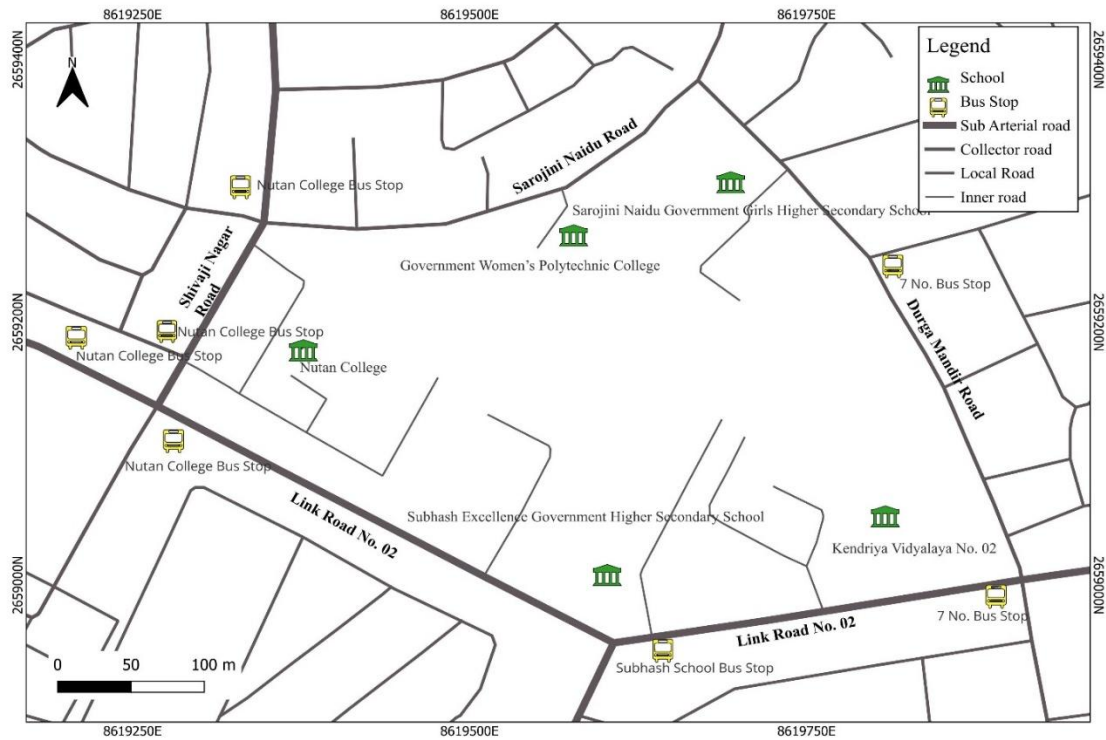


Fig. No. 17 Location of Schools and Bus stops

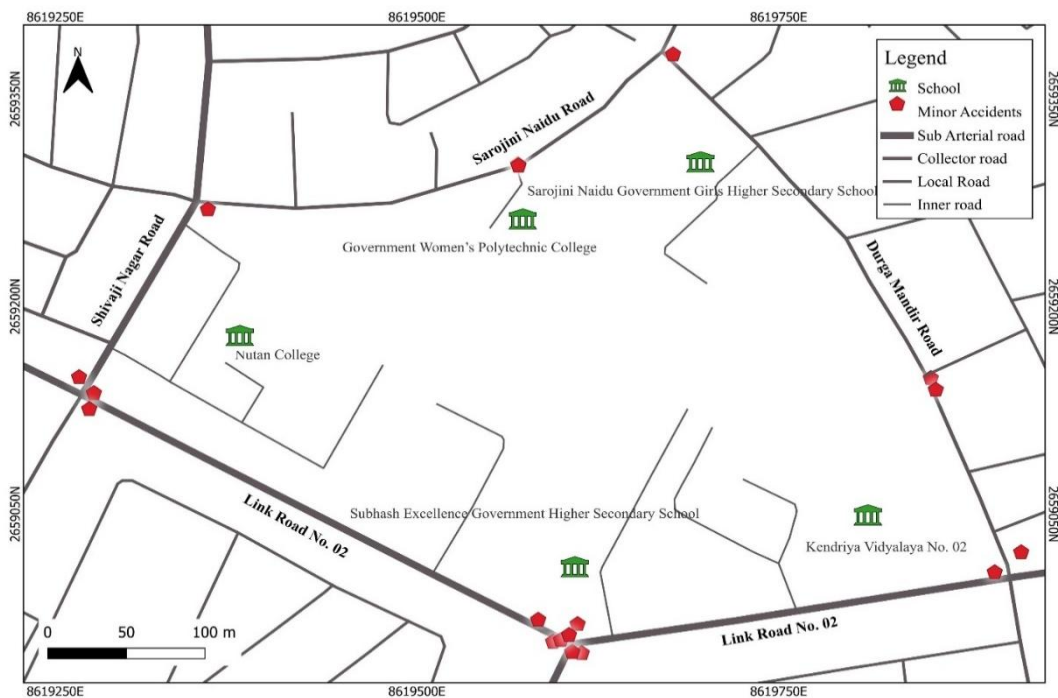
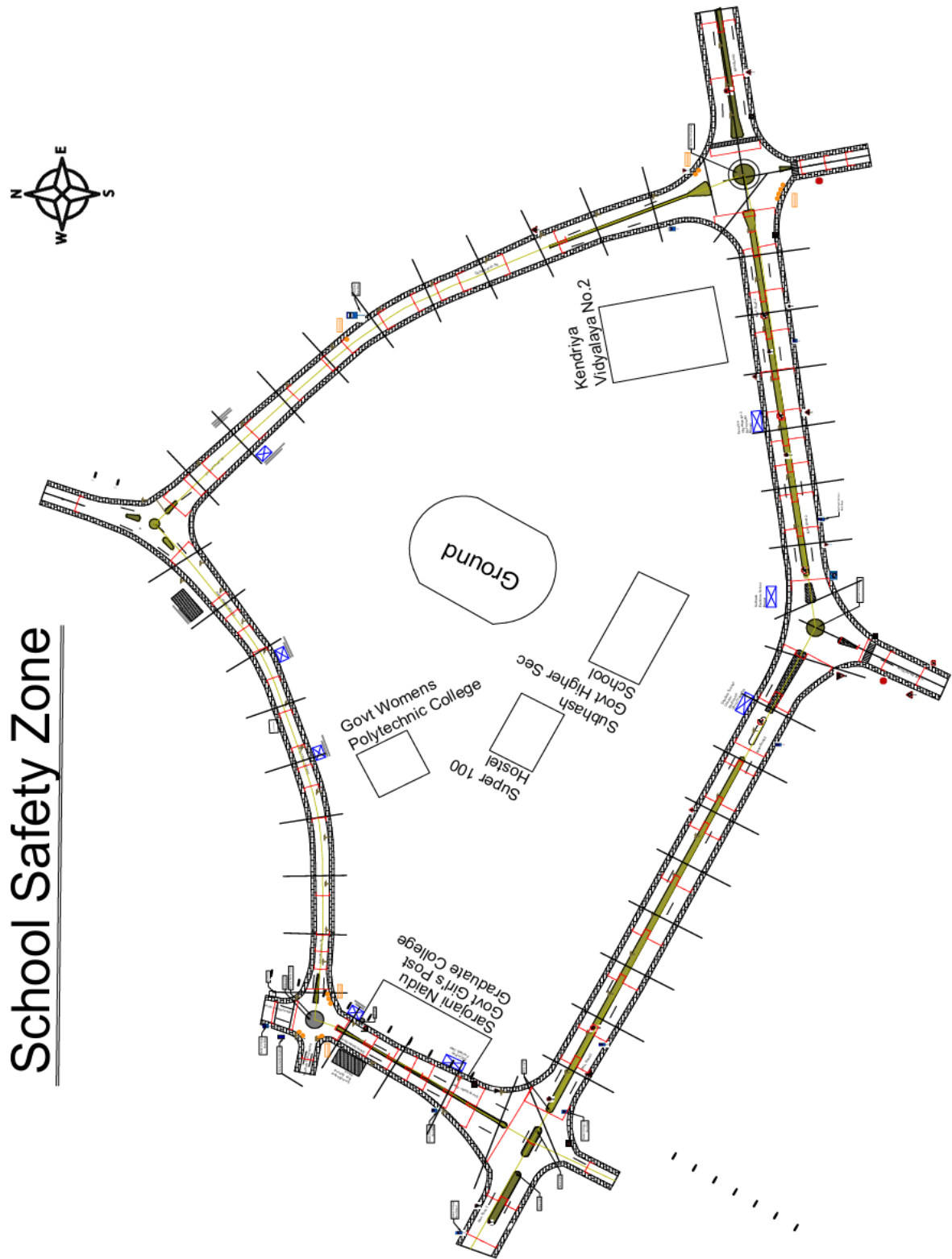


Fig. No. 18 Accident Spots

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School Safety Zone

Fig. No.19 AutoCAD Drawing

# SCHOOL ZONE SAFETY

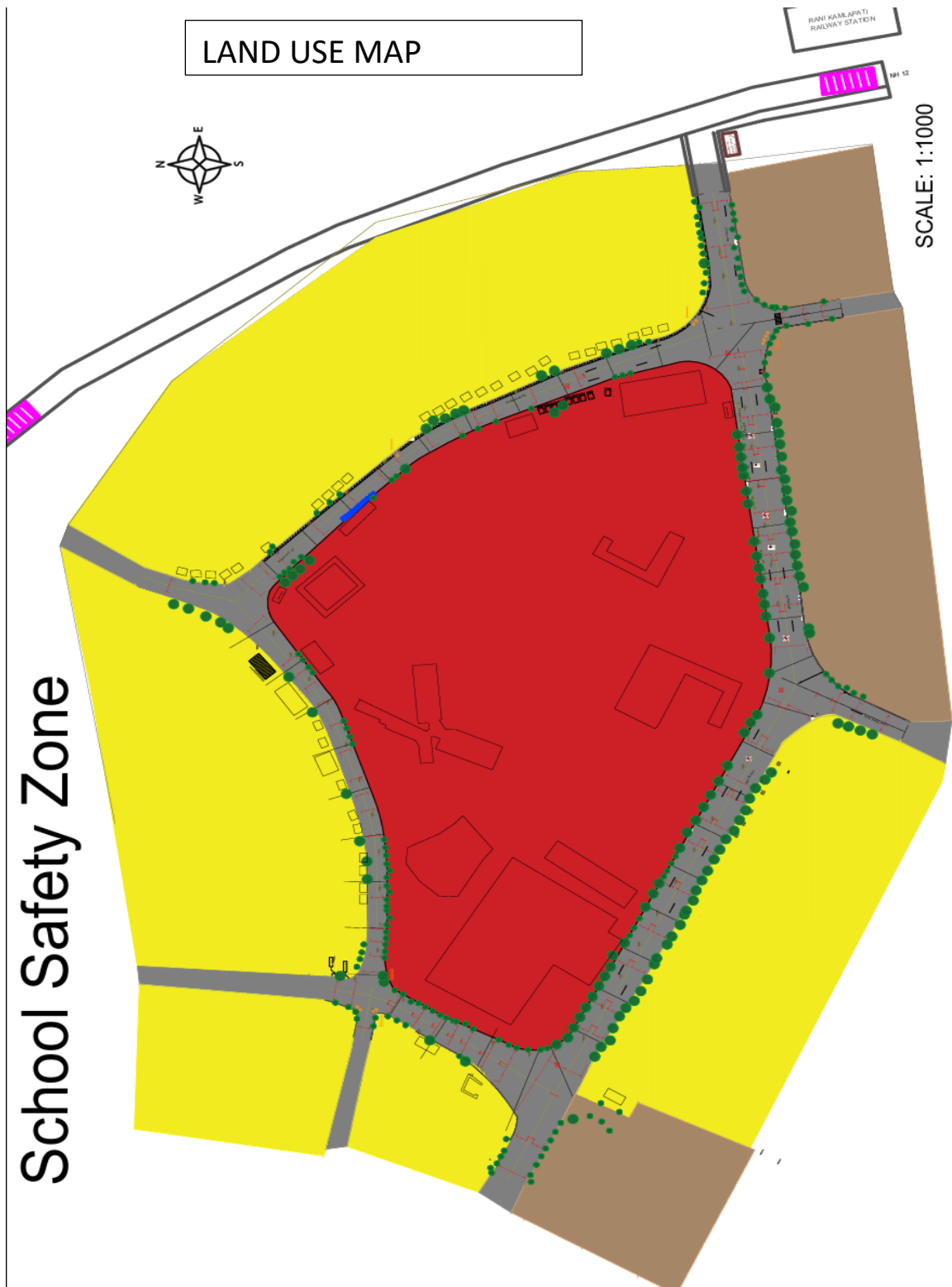
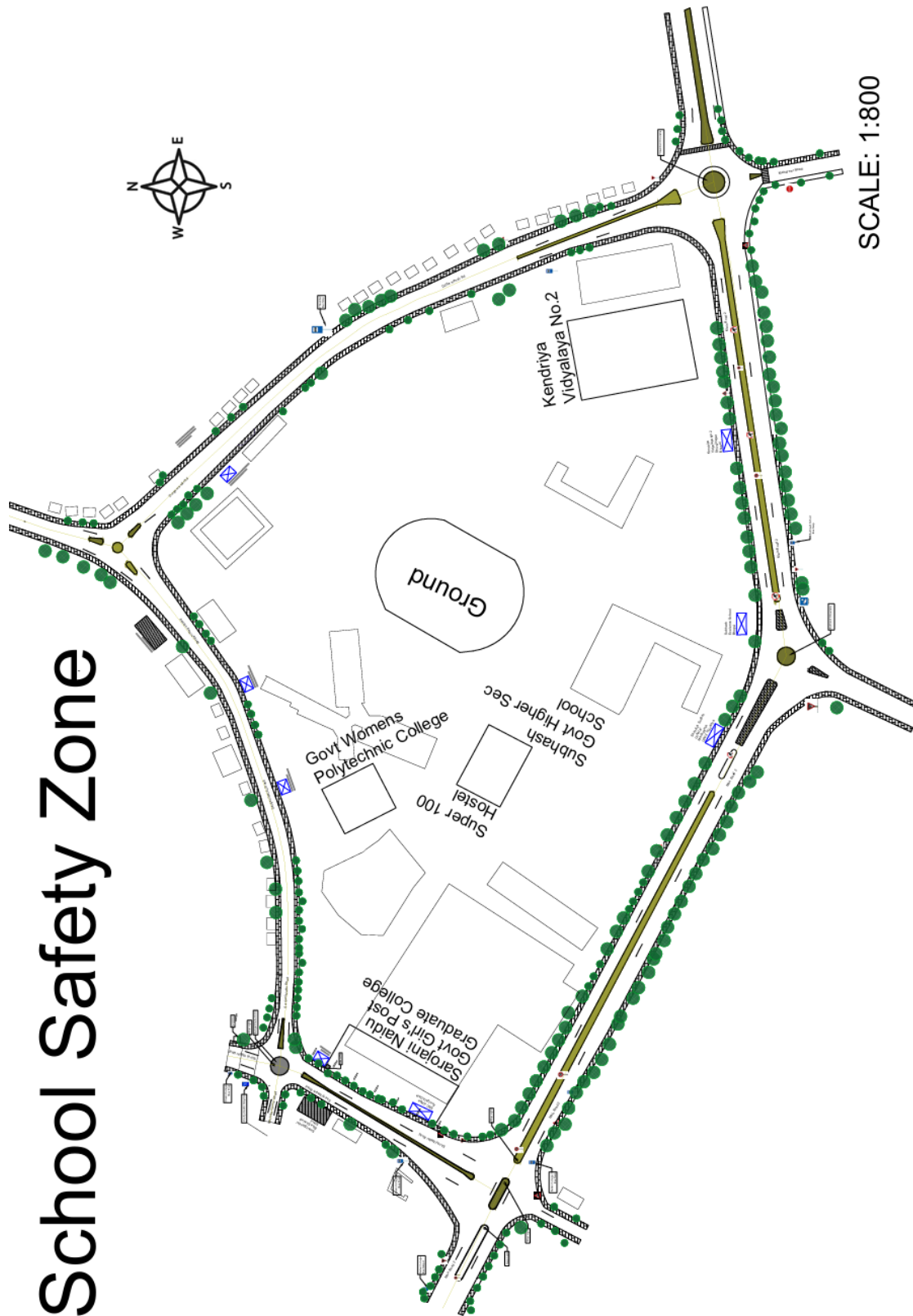


Fig. No.20 AutoCAD Drawing with Land use



# School Safety Zone

Fig. No.21 AutoCAD Drawing with Land use

## 4.1 Introduction

The analytical work presented in Chapter 3 established, through a combination of structured questionnaire surveys (n = 329), field infrastructure audits, and spatial conflict mapping, that the school zone environment in Shivaji Nagar, Bhopal is critically deficient across all dimensions of child road safety. The key findings that motivate the proposals in this chapter are summarised below.

**Table 4.2:** Summary of Key Analytical Findings (Chapter 3)

*Note. Source: Field survey, Shivaji Nagar, Bhopal, 2025–26.*

| Finding                                    | Indicator                                                                                                | Survey/Audit Source                           |
|--------------------------------------------|----------------------------------------------------------------------------------------------------------|-----------------------------------------------|
| Perceived vehicle speed is excessive       | 61.6% of respondents rated vehicles as 'very fast'; 23.3% as 'fast'. Only 16.6% rated speeds as 'normal' | Student and teacher perception survey (n=329) |
| Significant accident exposure              | 34.6% of respondents have personally witnessed or experienced a road accident near school                | Student survey                                |
| Unsafe road crossing                       | Walking on the road and crossing near school both rated 4/5 (unsafe) on the safety perception scale      | Student perception survey                     |
| School gate area is the highest-risk point | School gate frontage rated 2/5 — the lowest safety score of any school-zone situation assessed           | Student perception survey                     |
| No IRC-compliant raised crossings          | Zero raised pedestrian crossings at any of the five school gates in the study area                       | Field infrastructure audit                    |
| Fragmented or absent footpaths             | Estimated < 40% continuous footpath coverage in the School Proximal Zone (0–100 m from gates)            | Field audit                                   |
| No school zone signage                     | No 'School Ahead' (W-39) or speed limit signs on any approach road to the precinct                       | Field audit                                   |
| No formal pick-up/drop-off management      | Vehicles stop haphazardly in the live carriageway; no bays; no regulation                                | Field observation                             |
| No road safety education                   | None of the five schools has a structured road safety programme or Road Safety Club                      | School principal interviews                   |
| Near-universal demand for improvement      | 96.6% of respondents strongly agreed or agreed that safety improvements are urgently needed              | Student and teacher survey                    |

The proposals in this chapter respond systematically to these findings. Each proposal is traceable to a specific objective, and each objective is traceable to specific evidence from the field analysis. Where IRC guidelines prescribe a standard, that standard is cited in the

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text and detailed in the specification tables. Where case study precedent supports an intervention, the case is referenced.

The Indian Roads Congress defines three spatial zones around a school gate under IRC:SP:32-2023: the School Proximal Zone (SPZ, 0–100 m, speed limit 25 kmph); the School Transition Zone (STZ, 100–300 m, speed limit 30 kmph); and the School Access Zone (SAZ, 300–500 m, standard road limit). All proposals in this chapter are mapped to one or more of these zones.

A note on terminology: throughout this chapter, 'the precinct' refers to the five-school cluster in Shivaji Nagar treated as a single planning unit — Subhash Excellence Government Higher Secondary School, Kendriya Vidyalaya No. 2, Sarojini Naidu Government Girls Higher Secondary School, Government Women's Polytechnic College, and Nutan College. 'Gateway nodes' refers to the four primary intersections where the main access roads enter the school precinct.

### 4.2 Research Objectives

The following four objectives guide the planning proposals of this chapter. Each objective is framed in thesis-standard 'To...' form, is distinct in its scope, and is directly derived from the problem statement and evidence base established in Chapters 1 through 3.

#### 4.2.1 Speed Management and Traffic calming

**Objective 4.2.1:** To enforce uniform speed management in school zones by implementing Indian Roads Congress (IRC)-mandated speed limits of 20–30 km/h and introducing physical traffic calming measures — including raised pedestrian crosswalks, speed humps, rumble strips, gateway treatments, and kerb extensions — to achieve controlled and predictable vehicular movement throughout the School Proximal Zone (SPZ) and School Transition Zone (STZ).

Rationale: Survey data confirms that 84.9% of respondents perceive vehicle speeds near schools as 'fast' or 'very fast'. The field audit found no traffic calming device on any of the four primary approach roads to the precinct. IRC:SP:32-2023 mandates a maximum speed limit of 25 kmph in the SPZ and 30 kmph in the STZ; these limits are currently neither signed nor enforced. Research consistently demonstrates that reducing vehicle impact speed from 50 kmph to 25 kmph reduces pedestrian fatality probability from approximately 80% to less than 10% (IRC:99-2018, citing WHO data). Speed management is therefore the single highest-priority intervention in the school zone environment.

#### 4.2.2. Pedestrian and Non-Motorized Infrastructure

**Objective 4.2.2:** To strengthen pedestrian and non-motorized mobility infrastructure through the provision of continuous sidewalks, zebra crossings, guard rails, kerb ramps, and pedestrian refuge medians; and to promote walking and cycling as safe, preferred modes of school travel through dedicated cycle lanes, safe walking routes, and child-friendly urban design within the School Access Zone.

Rationale: The field audit found that fewer than 40% of the School Proximal Zone road network has a continuous, usable footpath. Students are routinely forced to walk on the active carriageway. IRC:103-2012 mandates a minimum footpath clear width of 1.5 m in school zones; no road segment within the precinct currently meets this standard. At the same time, 22% of students already walk to school and 10.8% cycle — modes that would increase further if infrastructure were safe and comfortable. The pedestrian and NMT proposals in Section 4.4 directly address this infrastructure gap.

#### 4.2.3 Zone Delineation and Enforcement

**Objective 4.2.3:** To standardize school zone delineation by establishing clear spatial boundaries, IRC:SP:32-compliant road signage, and carriageway markings; and to

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integrate enforcement mechanisms — including Traffic Regulation Orders, CCTV monitoring linked to the Bhopal Smart City ICCC, traffic police deployment at peak hours, and a community-based Safety Warden programme — to reduce speeding, illegal parking, and unsafe driver behaviour in the school zone.

Rationale: The school zone in Shivaji Nagar is currently invisible — there is no signage, road marking, or physical boundary that communicates to a driver that they are entering a zone with special rules. The NIMHANS Bengaluru study (cited in Chapter 2) found that only 17% of school zones nationally have any school zone signage; the Shivaji Nagar precinct falls in the 83% majority with none (Citizen Matters, 2019). Without clear delineation, enforcement is legally and practically impossible. The Motor Vehicles Amendment Act, 2019 provides authority for speed limit enforcement and parking prohibition; Traffic Regulation Orders under this Act are proposed as the legal foundation of the enforcement strategy.

### 4.2.4 Inclusive and sustainable Approaches

**Objective 4.2.4:** To foster inclusive, sustainable, and educational approaches to school zone safety by reducing vehicular emissions near schools through compact planning, green buffers, and climate-resilient infrastructure; and by engaging children, parents, and teachers in structured road safety education programmes while ensuring equitable access to transport infrastructure and urban amenities for all users, regardless of gender, age, or socio-economic status.

Rationale: Road safety in the school zone is not a purely physical problem. Survey data shows that no structured road safety education exists at any of the five institutions, and 84% of survey respondents are female — reflecting gendered safety concerns that require gender-sensitive design responses. Furthermore, the five schools share nearly identical start and end times, concentrating vehicular emissions during the same 30-minute windows in a zone where children are present and breathing. The National Road Safety Policy 2010 explicitly identifies school zones as priority zones for educational intervention; AMRUT 2.0 and the Smart Cities Mission identify NMT and green infrastructure as eligible capital investment components.

### 4.3 Speed Management and Traffic Calming

#### 4.3.1 The Three-Tier Speed Zone Framework

Speed management in the Shivaji Nagar Safe School Precinct is proposed as a three-tier hierarchy aligned to IRC: SP:32-2023's zone structure. Each tier has a defined speed limit, a specific set of calming devices, and a spatial extent. As shown in Table 4.3, the framework progressively reduces vehicle speeds from the prevailing road limit on the arterial network to 25 kmph at school gate frontages.

**Table 4.3:** Speed Management Zone Framework

*Note. Limits and devices per IRC: SP:32-2023, IRC:99-2018, and MV Amendment Act 2019.*

| Zone                         | Radius from Gate | Proposed Speed Limit             | Primary Calming Device                                  | Supplementary Device                          | Legal Instrument                      |
|------------------------------|------------------|----------------------------------|---------------------------------------------------------|-----------------------------------------------|---------------------------------------|
| School Access Zone (SAZ)     | 0–100 m          | 25 kmph (maximum)                | Raised table-top crossings at all school gates          | Bollards; no-parking enforcement; gate canopy | TRO-01; R-25 mandatory sign           |
| School Transition Zone (STZ) | 100–300 m        | 30 kmph (maximum)                | IRC Type-B sinusoidal speed humps at 85–100 m intervals | Rumble strips at zone entry; kerb extensions  | TRO-01; R-25 (30) sign                |
| School Proximal Zone (SPZ)   | 300–500 m        | Existing road limit (40–50 kmph) | Gateway treatment at zone entry                         | Advanced W-39 warning sign                    | Cautionary sign only; no TRO required |

#### 4.3.2 Raised Pedestrian Crossings (Table-Top Crosswalks)

Nine raised table-top crossings are proposed within the precinct: five at the individual school gate frontages (one per school, within the SPZ) and four at the gateway node intersections. A raised crossing simultaneously achieves two goals: it provides a safe, level-surface pedestrian crossing, and it physically compels approaching vehicles to reduce speed by ascending and descending a raised platform. (schematic section), the crossing consists of an approach ramp (gradient 1:10), a flat platform at 75–100 mm above the carriageway level, and a departure ramp on the far side.

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The choice of raised crossings over at-grade zebra crossings at school gates is supported by evidence from all three case studies reviewed in Chapter 2. In the Bengaluru YCARS intervention, raised crossings at school gates contributed to measurable improvement in road user compliance (Citizen Matters, 2021). In the New Delhi CROSSWALK initiative, raised crossings were central to the 'Space to Place' transformation of DDU Marg (HumanQind, 2024). In New York City's SRTS programme, raised crossings contributed to a 44% reduction in school-aged pedestrian injury rates (DiMaggio & Li, 2013).

The complete technical specification for raised crossings is provided in Appendix A, Table A1. Key parameters are reproduced below for reference.

**Table 4.4:** Raised Pedestrian Crossing — Key Design Parameters

*Note. Full specification in Appendix A, Table A1. Based on IRC:SP:32-2023 and IRC:99-2018.*

| Design Parameter                                 | Specification / Value                                                             | IRC / Standard Reference                    |
|--------------------------------------------------|-----------------------------------------------------------------------------------|---------------------------------------------|
| <b>Platform height</b>                           | 75 mm standard; 100 mm on high-speed approaches (> 40 kmph)                       | <i>IRC:99-2018 Cl. 5.4; IRC: SP:32-2023</i> |
| <b>Ramp gradient</b>                             | 1:10 maximum (10 cm rise per 1 m run)                                             | <i>IRC:99-2018 Cl. 5.4</i>                  |
| <b>Crossing width (perpendicular to traffic)</b> | 4,000 mm minimum; 6,000 mm at school gate crossings                               | <i>IRC: SP:32-2023 Cl. 7.2</i>              |
| <b>Platform length (in traffic direction)</b>    | 2,500–3,500 mm                                                                    | <i>IRC:99-2018 Table 1</i>                  |
| <b>Surface marking</b>                           | Zebra pattern, white thermoplastic, 500 mm stripes/gaps; glass-bead embedded      | <i>IRC:35-2015 Cl. 8.3</i>                  |
| <b>Tactile paving</b>                            | Yellow blister pattern, 600 mm wide, at both ramp transitions                     | <i>IS 15477; IRC:103-2012 Cl. 6.4</i>       |
| <b>Stop line position</b>                        | 1,500 mm upstream of ramp toe on approach side                                    | <i>IRC:35-2015 Cl. 9.1</i>                  |
| <b>Drainage</b>                                  | 150 × 150 mm V-channel at ramp base, full platform width, connected to kerb inlet | <i>IRC: SP:32-2023; IRC: SP:20</i>          |

### 4.3.3 Speed Humps within the Transition Zone

Within the STZ (100–300 m radius), a programme of IRC:99-2018 Type-B sinusoidal speed humps is proposed on all primary approach roads. Type-B humps (75 mm height, 3.7 m base length, smooth sinusoidal profile) are specified over the steeper Type-A hump because they are more comfortable at compliant speeds (25–30 kmph) while still creating significant discomfort above 40 kmph. As shown in Table 4.5, twelve humps are proposed across four road segments, with additional Type-C flat-top raised sections serving dual function as pedestrian crossings on internal precinct roads.

**Table 4.5:** Speed Hump Programme — School Transition Zone

*Note. IRC:99-2018 Type specifications. Spacings measured from SPZ boundary.*

| Road Segment                                        | No. of Humps | Spacing from SPZ Boundary | IRC Type                        | Supplementary Measure                             |
|-----------------------------------------------------|--------------|---------------------------|---------------------------------|---------------------------------------------------|
| Link Road No. 2 (southbound approach)               | 3            | 85 m, 175 m, 265 m        | Type-B sinusoidal               | Rumble strip at 295 m; gateway treatment at 300 m |
| Sarojini Naidu Road (eastern approach)              | 3            | 90 m, 185 m, 280 m        | Type-B sinusoidal               | Rumble strip at 295 m; W-39 sign at 300 m         |
| Durga Mandir Road (KV No. 2 approach)               | 2            | 80 m, 200 m               | Type-B sinusoidal               | Gateway narrowing at 300 m                        |
| Internal access road (north–south, within precinct) | 2            | 60 m, 120 m               | Type-C flat-top (dual crossing) | Pedestrian crossing function integrated           |

Rumble strips (IRC:99-2018 type) are proposed at the STZ entry boundary on each approach road. These consist of a series of transverse raised thermoplastic strips (75 mm wide, 12 mm height, 300 mm spacing, full carriageway width) that provide both auditory and tactile warning to drivers that they are entering the school zone. The full rumble strip specification is provided in Appendix A, Table A2.

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### 4.3.4 Gateway Treatments

Four gateway treatment packages are proposed at the intersections where the primary access roads enter the precinct. As shown in Table 4.6, each gateway package consists of five integrated components that together create an unambiguous physical and visual transition into the school zone.

**Table 4.6:** Gateway Treatment Package — Components and Specification

*Note. Applied at all four gateway nodes: Subhash Chowraha, 7 Number Chowraha, KV Link Road junction, and Nutan College western approach.*

| Component                        | Description                                                                                                                                                                              | IRC / Standard Reference                    |
|----------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------|
| 1. Carriageway narrowing         | Kerb extension of 1.5–2.0 m on both sides of the approach, reducing effective carriageway width and pedestrian crossing distance. Detailed specification in Appendix A, Table A3.        | IRC:103-2012 Cl. 5.8                        |
| 2. Surface texture/colour change | 5-metre transverse band of red anti-skid coloured thermoplastic surfacing across the full carriageway width at the gateway entry, providing visual and tactile entry signal.             | IRC: SP:32-2023 recommended practice        |
| 3. School zone portal signage    | Paired portal sign structure on each kerb side: 'SHIVAJI NAGAR SAFE SCHOOL PRECINCT — Speed 25 km/h — 7:00 AM–5:00 PM'. R-25 mandatory speed limit sign co-mounted at 2.2 m height.      | IRC:67-2012; IRC: SP:32-2023                |
| 4. Raised table at gateway       | Raised table-top crossing (Type-C, flat-top, 75–100 mm) spanning the full carriageway width at the gateway pinch point. Functions as pedestrian crossing and physical speed enforcement. | IRC:99-2018 Cl. 5.5; IRC: SP:32-2023        |
| 5. Planted gateway feature       | Two trees or 600 mm height shrub planting in kerb extension zone, reinforcing the zone boundary visually and providing physical protection against vehicle overrun onto the footpath.    | IRC:103-2012; BMC Urban Greening Guidelines |

### 4.3.5 Raised Junction — Subhash Chowraha

Subhash Chowraha, where Link Road No. 2 meets the internal precinct access road adjacent to two school gates, is the highest-risk intersection in the study area. A raised

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junction treatment — elevating the entire intersection to footpath level — is proposed. Unlike a simple raised crossing on one arm, a raised junction treats the entire intersection as a pedestrian-priority surface: vehicles must ascend a ramp on all approach arms before traversing the junction, reducing their speed to 8–12 kmph and establishing unambiguous pedestrian priority throughout the junction area. Key parameters are given in Table 4.7; the full specification is in Appendix A, Table A4.

The raised junction concept is consistent with IRC:99-2018's Type-C raised section provisions and with the design principles articulated in IRC:SP:32-2023 for School Proximal Zone intersections. It is also consistent with international best practice in Vision Zero cities, where raised junctions at school zone intersections are standard practice (WHO, 2021).

**Table 4.7:** Raised Junction — Subhash Chowraha: Key Design Parameters

*Note. Full specification in Appendix A, Table A4.*

| Parameter                     | Specification                                                                                                                                  |
|-------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------|
| Platform elevation            | 100 mm above surrounding carriageway (matching footpath level on all junction arms)                                                            |
| Ramp gradient (all four arms) | 1:10 maximum; ramp length 1,000 mm for 100 mm platform                                                                                         |
| Platform surface              | Exposed aggregate concrete or block paving, red/buff colour; anti-skid texture mandatory; IRC:35-2015 zebra markings on all four crossing arms |
| Drainage                      | Perimeter V-channel (150 × 150 mm) around junction platform; four channel inlets at ramp bases                                                 |
| Structural specification      | M30 PCC, 300 mm depth on compacted wet mix macadam base; design wheel load 10 tonnes                                                           |
| Night visibility              | Retro-reflective flexible delineator posts (900 mm, orange) at all four junction corners                                                       |

### 4.3.6 Signalized Crossing with Leading Pedestrian Interval — 7 Number Chowraha

At 7 Number Chowraha on Sarojini Naidu Road — the primary access intersection for Sarojini Naidu Girls School and Government Women's Polytechnic College — a signalized pedestrian crossing with a Leading Pedestrian Interval (LPI) is proposed. The LPI is a signal phase modification that provides pedestrians with an exclusive 7-second head start before conflicting vehicle movements receive a green signal. This eliminates the most common form of pedestrian-vehicle conflict at signalized junctions: turning vehicles striking pedestrians who have simultaneously received a 'WALK' signal.

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This approach is directly drawn from the NYC Safe Routes to School programme, where LPIs contributed measurably to the 44% reduction in school-aged pedestrian injuries (DiMaggio & Li, 2013). The LPI concept is applicable under the IRC signal design framework and does not require bespoke hardware beyond accessible push-button units and countdown display heads. Key parameters are given in Table 4.8.

**Table 4.8:** LPI Signal Design — 7 Number Chowraha

*Note. Based on NYC DOT LPI Standard adapted to IRC:67-2012 and IRC:103-2012.*

| Parameter                          | Specification                                                                                             | Reference                                  |
|------------------------------------|-----------------------------------------------------------------------------------------------------------|--------------------------------------------|
| <b>LPI duration</b>                | 7 seconds exclusive pedestrian phase before vehicle green                                                 | NYC DOT LPI Standard; IRC:67 signal timing |
| <b>Pedestrian push-button</b>      | Accessible height 900–1,000 mm; audible bleep confirmation; tactile direction arrow on unit face          | IRC:103-2012 Cl. 8.5                       |
| <b>Pedestrian signal head</b>      | LED countdown display (seconds remaining); international WALK/DON'T WALK symbols; 2,200 mm above footpath | IRC:67-2012 Cl. 12                         |
| <b>Minimum crossing time</b>       | Road width (m) ÷ 1.0 m/s (child walking speed); not less than 8 seconds for 8 m carriageway               | IRC:103-2012 Cl. 8.4                       |
| <b>Kerb extensions at crossing</b> | 1.5 m projection on each side, reducing 8 m crossing to 5 m effective crossing width                      | IRC:103-2012                               |

Together, the nine raised crossings, twelve speed humps, eight rumble strip installations, and four gateway treatments proposed in this section create a comprehensive speed management corridor throughout the precinct. No vehicle travelling through the School Proximal Zone will be able to maintain speeds above 25 kmph without deliberate, illegal effort — and the simultaneous enforcement measures proposed in Section 4.5 ensure that such deliberate non-compliance carries meaningful consequences.

## 4.4 Pedestrian and Non-Motorized Infrastructure

### 4.4.1 Continuous Footpath Network

A continuous, IRC:103-2012-compliant footpath network is the most critical single infrastructure improvement for the study area. The field audit found that fewer than 40% of the SPZ and STZ road network has a usable footpath. The proposed footpath network provides a complete, unobstructed pedestrian walkway along all road segments used by students within a 300-metre radius of the school gates — approximately 2,100 linear metres of footpath construction or restoration on both sides of primary roads.

As detailed in Table 4.9, the footpath standard varies by location: a 2.4-metre clear width is specified at school frontages (accommodating peak-hour bidirectional child pedestrian flow); 1.8 metres on SPZ general roads; and 1.5 metres in the STZ. All sections include a 500-millimetre buffer strip between the footpath clear width and the carriageway edge, used for tree planting, bollards, and utilities — keeping these obstructions out of the pedestrian path. The complete footpath design specification is provided in Appendix A, Table A5.

**Table 4.9:** Footpath Width Standards by Zone

*Note. Per IRC:103-2012 Cl. 5.2 and IRC: SP:32-2023 Cl. 7.4. All widths refer to unobstructed clear walking width.*

| Zone / Location                | Clear Footpath Width | Buffer Strip Width | Total Footway Width | Justification                                                                               |
|--------------------------------|----------------------|--------------------|---------------------|---------------------------------------------------------------------------------------------|
| School frontage (5 gates, SPZ) | 2,400 mm             | 500 mm             | 2,900 mm            | Bidirectional peak-hour flow of 200–400 students in < 30 minutes; IRC:SP:32 preferred width |
| SPZ general (non-frontage)     | 1,800 mm             | 500 mm             | 2,300 mm            | IRC:103 preferred width for school zones; allows two adults with bags to pass               |

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| Zone / Location         | Clear Footpath Width | Buffer Strip Width | Total Footway Width | Justification                                |
|-------------------------|----------------------|--------------------|---------------------|----------------------------------------------|
| STZ (100–300 m)         | 1,500 mm             | 500 mm             | 2,000 mm            | IRC:103 minimum for school zones             |
| SAZ safe walking routes | 1,500 mm             | 300 mm min         | 1,800 mm min        | IRC:103 minimum; upgraded where space allows |

Footpath encroachment by informal vendors, parked vehicles, and utility boxes is a primary cause of the existing unusable condition. A systematic encroachment clearance programme is proposed as Phase 1 of implementation (Section 4.7), coordinated by BMC Zone Office and Traffic Police. Encroachments within 50 metres of each school gate are to be cleared as an immediate priority.

### 4.4.2 Kerb Ramps

Kerb ramps (dropped kerbs) are proposed at all 16 crossing approach points within the SPZ and STZ — both sides of each of the 8 proposed zebra crossings. Without kerb ramps, the 150 mm upstand kerb between the footpath and the carriageway creates a barrier that is particularly difficult for young children to navigate while carrying school bags, and completely impassable for wheelchair users or students with mobility impairments. Table 4.10 summarizes the key kerb ramp design parameters; full specification is in Appendix A, Table A6.

**Table 4.10:** Kerb Ramp — Key Design Parameters

*Note. Per IRC:103-2012 Cl. 6.3 and IS 15477.*

| Parameter | Specification                                                             |
|-----------|---------------------------------------------------------------------------|
| Gradient  | 1:12 maximum (preferred 1:16 for children and wheeled mobility devices)   |
| Width     | 1,200 mm minimum; equal to crossing width where crossing width < 1,500 mm |

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| Parameter                       | Specification                                                                                               |
|---------------------------------|-------------------------------------------------------------------------------------------------------------|
| Level landing at footpath level | 1,500 mm × 1,500 mm flat landing before ramp commences                                                      |
| Surface                         | Brushed concrete or anti-skid textured paving; friction coefficient $\geq 0.5$ (wet condition, per IS 9284) |
| Tactile warning strip           | Blister-pattern, yellow, 600 mm wide, at top and bottom of ramp                                             |
| Grade break at base             | Maximum 13 mm vertical offset between ramp base and carriageway surface; must be flush                      |

### 4.4.3 Guard Rails

Pedestrian guard rails are proposed along all school gate frontages and at the approaches to every raised crossing within the SPZ. Guard rails serve two evidence-based functions: they prevent children from stepping impulsively off the footpath into the carriageway (a behavior well documented in the child pedestrian safety literature for children under 12, attributed to incomplete risk-assessment capacity — see Petzoldt, 2014), and they channel pedestrian flow toward designated crossing points. As shown in Table 4.11, guard rails are specified to a standard that provides meaningful physical resistance while maintaining large openings at school gate entries and crossing points.

**Table 4.11:** Guard Rail — Design Parameters

*Note. Per IRC:5-2015 and IRC:SP:32-2023.*

| Parameter      | Specification                                                                                    |
|----------------|--------------------------------------------------------------------------------------------------|
| Rail height    | 1,200 mm; horizontal rails at 400 mm, 700 mm, and 1,100 mm above footpath level                  |
| Post spacing   | 2,000 mm centre-to-centre maximum                                                                |
| Post embedment | 600 mm into concrete footing (300 × 300 × 500 mm, M20 PCC)                                       |
| Surface finish | Hot-dip galvanized + yellow/black retro-reflective banding (300 mm intervals, Type-III sheeting) |

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| Parameter              | Specification                                                                                                 |
|------------------------|---------------------------------------------------------------------------------------------------------------|
| Opening at crossing    | 4,000 mm minimum, aligned exactly with crossing — no staggered opening                                        |
| Opening at school gate | 6,000 mm minimum clear opening at each school gate                                                            |
| Locations proposed     | All 5 school gate frontages (full 30–50 m width each side of gate); 25 m approaches to all 9 raised crossings |

### 4.4.4 Pedestrian Refuge Islands

On three road segments within the SPZ where the carriageway width exceeds 7 metres — the Sarojini Naidu Road mid-section, the Link Road No. 2 school frontage, and the Subhash Chowraha arm of the internal access road — central pedestrian refuge islands are proposed at the crossing locations. A refuge island allows a pedestrian who cannot cross the full carriageway width in a single gap (in particular, young children who move more slowly and have shorter perceptual windows for gap acceptance) to wait safely in the centre of the road. Table 4.12 gives the key refuge island parameters.

**Table 4.12:** Pedestrian Refuge Island — Design Parameters

*Note. Per IRC:103-2012 Cl. 5.8.*

| Parameter | Specification                                                                           |
|-----------|-----------------------------------------------------------------------------------------|
| Width     | 1,200 mm minimum; 1,800 mm preferred (comfortable waiting space for adult and child)    |
| Length    | 4,000 mm minimum (pedestrians standing within refuge, clear of both traffic lanes)      |
| Elevation | At footpath level (100–150 mm above carriageway); flush kerb ramps (1:12) on both sides |

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| Parameter       | Specification                                                                                               |
|-----------------|-------------------------------------------------------------------------------------------------------------|
| Guard rail      | Longitudinal guard rails on both long sides to prevent stepping into traffic lane                           |
| Number proposed | 3 (Sarojini Naidu Road mid-section; Link Road No. 2 frontage; internal access road at Subhash Chowraha arm) |

### 4.4.5 Zebra Crossings

Formal zebra crossings conforming to IRC:35-2015 are proposed at all crossing locations within the SPZ and STZ — nine on raised crossings and thirteen at-grade crossings within the STZ. As shown in Table 4.13, a school-zone zebra crossing differs from a standard crossing in minimum width (4,000 mm vs 2,500 mm standard), the mandatory co-location with a kerb ramp, and the requirement for glass-bead embedded thermoplastic for enhanced retroreflectivity. Zebra crossings at raised crossings are applied directly to the platform surface.

**Table 4.13:** Zebra Crossing — Key Design Parameters

*Note. Per IRC:35-2015 Cl. 8.3 and IRC:SP:32-2023.*

| Parameter         | Specification                                                                                        |
|-------------------|------------------------------------------------------------------------------------------------------|
| Stripe dimensions | 500 mm white thermoplastic; 500 mm gaps between stripes                                              |
| Crossing width    | 4,000 mm minimum; 6,000 mm at school gate crossings (high pedestrian volume)                         |
| Material          | Class-B thermoplastic compound; glass-bead content $\geq 800$ g/m <sup>2</sup> for retroreflectivity |
| Stop line         | White thermoplastic, 300 mm wide, 1,500 mm upstream of first stripe on approach side                 |

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| Parameter                  | Specification                                                                 |
|----------------------------|-------------------------------------------------------------------------------|
| Advance 'SLOW' text        | Stencilled 30 m before crossing; 2,400 mm letter height, yellow thermoplastic |
| Retroreflective road studs | Embedded along outer edges of crossing; 500 mm spacing; IRC:35-2015 Cl. 10    |
| Total crossings proposed   | 22 (9 on raised crossings; 13 at-grade within STZ)                            |

### 4.4.6 Non-Motorized Transport Infrastructure

#### 4.4.6.1 Safe Walking Routes

Four designated Safe Walking Routes (Routes W1–W4) are proposed within the School Access Zone, connecting the primary residential catchment areas identified from the student origin survey data to the precinct gates. As shown in Table 4.14, each route is specified with its corridor, key infrastructure improvements, approximate length, and estimated daily users. All routes are assessed against IRC:SP:32-2023's SAZ walking quality criteria (continuous footpath, minimum 1.5 m; formal crossing at every road crossing; street lighting; direct alignment to school gate).

**Table 4.14:** Safe Walking Route Network — Routes W1 to W4

*Note. Based on student origin survey data and field observation, 2025–26.*

| Route        | Corridor                                                                             | Length | Key Infrastructure Improvements                                            |
|--------------|--------------------------------------------------------------------------------------|--------|----------------------------------------------------------------------------|
| W1 — Western | Junior MIG Colony / Shankar Nagar → Nutan College / Subhash School via internal road | 480 m  | 80 m missing footpath link; 2 zebra crossings; 3 streetlights; 3 WSB stops |

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|                    |                                                                               |       |                                                                                         |
|--------------------|-------------------------------------------------------------------------------|-------|-----------------------------------------------------------------------------------------|
| W2 — Northern      | Northern residential (Sarojini Naidu Road north side) → Sarojini Naidu School | 350 m | Mid-block raised crossing; 120 m footpath restoration; 2 WSB stops                      |
| W3 — Southern Link | Link Road No. 2 bus stops → Subhash School / KV No. 2                         | 300 m | 150 m new footpath on Link Road shoulder; improved bus stop; 2 zebra crossings          |
| W4 — Eastern       | Durga Mandir Road residential → Kendriya Vidyalaya No. 2                      | 420 m | 4 kerb ramps; 1 zebra crossing at Durga Mandir Road junction; 90 m footpath restoration |

Each route is physically identified on the ground through route marker signs ('Safe Walking Route to Schools'), WSB Stop signs at fixed collection points, and continuous footpath infrastructure throughout. The routes are designed to be independently navigable by a child of 9 years without adult supervision — the standard implied by IRC:SP:32-2023 for a compliant School Access Zone.

### 4.4.6.2 Cycling Infrastructure

A dedicated, buffered cycle lane is proposed along the eastern side of Link Road No. 2 and the southern section of Sarojini Naidu Road — 650 metres in total — serving the 10.8% of students who currently cycle and providing conditions that can increase this proportion. The lane is specified as a 'buffered cycle lane' (painted with physical delineator posts, 500 mm buffer from the motor vehicle lane) rather than a physically separated cycle track, since the latter would require land acquisition beyond available road width. As shown in Table 4.15, the lane is 1.5 metres wide, marked in green thermoplastic, and fitted with retro-reflective delineator posts at 5-metre spacing within the SPZ.

**Table 4.15:** Cycling Corridor — Key Design Parameters

*Note. Per IRC:SP:43 and MoRTH NMT Guidelines 2021.*

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| Parameter                             | Specification                                                                                                   |
|---------------------------------------|-----------------------------------------------------------------------------------------------------------------|
| <b>Cycle lane width</b>               | 1,500 mm minimum (preferred 1,800 mm); measured from edge line to carriageway line                              |
| <b>Buffer from motor vehicle lane</b> | 500 mm; fitted with flexible delineator posts                                                                   |
| <b>Delineator spacing</b>             | 5 m within SPZ; 10 m within STZ                                                                                 |
| <b>Surface marking</b>                | Green thermoplastic edge lines (300 mm min width); bicycle pictogram at 20 m intervals                          |
| <b>Cycle parking</b>                  | Inverted-U racks (4-cycle per unit, 5 units = 20 cycles) at each school gate; within CCTV-covered frontage zone |
| <b>Total length</b>                   | 650 m (430 m on Link Road No. 2; 220 m on Sarojini Naidu Road)                                                  |

### 4.4.6.3 Walking School Bus Programme

The Walking School Bus (WSB) is an organised, adult-supervised group walking programme in which children travelling within walking distance of school join a supervised group at scheduled collection points, walking together along designated safe routes. This model was successfully implemented in the New Delhi CROSSWALK initiative (HumanQind, 2024) and in comparable programmes in Bengaluru and Chennai. Evidence from these programmes suggests that WSBs can shift 8–15% of motorised school journeys to walking within the first two academic years.

The WSB programme for Shivaji Nagar is proposed on all four walking routes, operated by two trained parent volunteers per route during morning and afternoon school hours. Students wear a high-visibility vest (yellow) during WSB participation; supervisors wear an orange vest marked 'School Safety Warden'. Stop points are at 100–150 m intervals on each route, identified by dedicated pole-mounted WSB Stop signs. A simple daily attendance register provides accountability and programme monitoring data. Programme coordination is managed by the School Zone Safety Committee (described in Section 4.8).

## 4.4.7 Pick-up and Drop-off Bay System

Survey data shows that 46.4% of students commute by auto-rickshaw or shared van, and 11.6% by private motorcycle. These vehicles currently stop haphazardly in the live carriageway at school gate frontages during peak hours, creating the single most concentrated conflict zone in the precinct. A formal pick-up/drop-off bay system is proposed at each of the five school gates. As shown in Table 4.16, each bay provides four to five vehicles simultaneously, is physically separated from the active traffic lane by a kerb, and includes a protected pedestrian pathway from the bay to the school gate. The complete bay design specification is in Appendix A, Table A7.

**Table 4.16:** Pick-up/Drop-off Bay — Key Design Parameters

*Note. Per IRC:SP:32-2023 Cl. 8.2.*

| Parameter                   | Specification                                                                                                                         |
|-----------------------------|---------------------------------------------------------------------------------------------------------------------------------------|
| Bay length                  | Minimum 30 m (5 vehicles at 6 m/vehicle)                                                                                              |
| Bay width                   | 2,500 mm parallel to carriageway; separated from active lane by 150 mm upstand kerb                                                   |
| Pedestrian path through bay | 1,200 mm marked path between vehicle side and school gate, protected by low kerb or delineators                                       |
| Surface markings            | Yellow box hatching; numbered stalls (1–5); directional arrows; 'LOADING ZONE' text                                                   |
| Signage                     | School-specific informatory board: operating hours, bay capacity, no-parking at all other times                                       |
| Auto-rickshaw staging       | Separate 15-vehicle staging area on Link Road No. 2 eastern shoulder, 100 m from nearest school gate; shade structure; drinking water |

## 4.5 School Zone Delineation and Enforcement

### 4.5.1 Rationale for Zone Delineation

A school zone that is physically present but visually invisible — with no signage, no boundary marking, and no distinctive road environment — cannot be effectively enforced. The field audit confirmed that the Shivaji Nagar precinct has no IRC:67-2012-compliant school zone signs on any approach road, no IRC:35-2015 school zone road markings, and no defined spatial boundary. This section proposes a complete delineation and enforcement system organised around three complementary components: physical zone marking (signs and road markings that define boundaries and communicate rules); active enforcement (Traffic Regulation Orders, CCTV surveillance, and police deployment); and community vigilance (Safety Wardens).

### 4.5.2 School Zone Boundary Delineation

The SPZ boundary (100 m radius from each school gate) and STZ boundary (300 m radius) are proposed to be physically marked on all approach roads through the entry demarcation package described in Table 4.17. As shown, the SPZ entry package includes five components ranging from mandatory speed signs to a surface colour band; the STZ entry package is lighter but still clearly visible.

**Table 4.17:** School Zone Entry Demarcation Package

*Note. Per IRC:SP:32-2023, IRC:67-2012, and IRC:35-2015.*

| Component            | SPZ Entry (at 100 m / gateway)                                                             | STZ Entry (at 300 m)                                    |
|----------------------|--------------------------------------------------------------------------------------------|---------------------------------------------------------|
| Mandatory speed sign | R-25 '25 kmph' mandatory sign; 600 × 600 mm; Grade III retroreflective; both sides of road | R-25 '30 kmph' mandatory sign; 600 × 600 mm; both sides |

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| Component                    | SPZ Entry (at 100 m / gateway)                                                                        | STZ Entry (at 300 m)                                    |
|------------------------------|-------------------------------------------------------------------------------------------------------|---------------------------------------------------------|
| School zone identifier board | 'SHIVAJI NAGAR SAFE SCHOOL PRECINCT — Speed 25 km/h — 7:00 AM–5:00 PM'; 900 × 600 mm; blue background | 'SCHOOL ZONE AHEAD — Reduce Speed' informatory board    |
| Carriageway text             | 'SCHOOL ZONE' stencilled transversely; white thermoplastic; 2,400 mm letter height                    | 'SCHOOL ZONE AHEAD — REDUCE SPEED'; white thermoplastic |
| Speed limit numeral on road  | '25' speed numeral; 1,200 mm height; at gateway entry                                                 | '30' speed numeral at STZ entry; on each approach       |
| Surface colour band          | 5 m red anti-skid thermoplastic band across full carriageway width                                    | Not required                                            |
| Raised table at gateway      | Type-C raised crossing (full specification in Section 4.3.4 and Appendix A, Table A4)                 | Not required — speed humps serve calming function       |

### 4.5.3 Signage Package

A complete signage package of 126 signs (Table 4.18) is proposed for the precinct, covering all IRC:67-2012 sign categories relevant to school zones: cautionary (W-series), mandatory (R-series), and informatory (D-series). All signs are specified with Class III retro-reflective sheeting and aluminum alloy faces (minimum 2 mm thickness). The full sign schedule is provided in Appendix A, Table A8.

**Table 4.18:** Signage Package Summary

*Note.* IRC:67-2012 sign codes. Full schedule in Appendix A, Table A8.

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| Sign Code      | Description                            | Size         | Quantity | Key Location(s)                                           |
|----------------|----------------------------------------|--------------|----------|-----------------------------------------------------------|
| R-25 (25 kmph) | Mandatory speed limit — SPZ            | 600 × 600 mm | 8        | SPZ boundary on each approach (2 sides × 4 approaches)    |
| R-25 (30 kmph) | Mandatory speed limit — STZ            | 600 × 600 mm | 8        | STZ entry on each approach                                |
| W-39           | Cautionary — School Ahead              | 600 × 600 mm | 8        | 300 m before each school gate on all approaches (2 sides) |
| W-14           | Cautionary — Pedestrian Crossing Ahead | 600 × 600 mm | 44       | 50 m before each of 22 crossings (2 approach sides each)  |
| R-3            | Mandatory — No Parking                 | 450 × 450 mm | 20       | Both sides of each school gate, 25 m each side (5 gates)  |
| R-4            | Mandatory — No Stopping                | 450 × 450 mm | 10       | Carriageway side facing each pick-up/drop-off bay         |
| D-28 (custom)  | Informatory — School Zone Precinct     | 900 × 600 mm | 8        | All 4 gateway nodes (entry and exit, 2 sides each)        |
| Custom Info    | Pick-up/Drop-off Bay identifier        | 600 × 400 mm | 5        | At entry to each school bay                               |
| Custom Info    | Safe Walking Route marker              | 400 × 300 mm | 40 est.  | Every 100 m along Routes W1–W4                            |
| Custom Info    | WSB Stop sign                          | 300 × 300 mm | 24 est.  | At each Walking School Bus stop (approx. 6 per route)     |

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### 4.5.4 Pavement Markings Package

The pavement markings package complements the signage package at ground level, providing continuous visual communication with road users. All markings conform to IRC:35-2015. As shown in Table 4.19, the package covers 12 marking types applied across approximately 9,200 linear metres and 550 square metres of carriageway surface within the precinct. The most critical markings — 'SCHOOL ZONE' text, zebra crossings, and no-parking yellow kerb lines — are Phase 1 interventions implementable within the first three months at low cost.

**Table 4.19:** Pavement Markings Package — Summary

*Note. Per IRC:35-2015. Full schedule in Appendix A, Table A9.*

| Marking Type                     | Specification                                                              | Quantity / Extent                 | Phase |
|----------------------------------|----------------------------------------------------------------------------|-----------------------------------|-------|
| 'SCHOOL ZONE' carriageway text   | White thermoplastic; 2,400 mm letters; transverse across lane              | 4 installations (one per gateway) | 1     |
| 'SLOW' carriageway text          | White thermoplastic; 2,400 mm letters; 30 m before each gate and crossing  | 27 installations                  | 1     |
| Speed limit numerals ('25'/'30') | White thermoplastic; 1,200 mm numerals; at zone boundaries and every 150 m | 12 installations                  | 1     |
| Zebra crossing stripes           | White thermoplastic; 500 mm stripes/gaps; glass-bead embedded              | 22 crossings; est. 176 m total    | 2     |
| Stop lines                       | White thermoplastic; 300 mm wide; 1,500 mm before each crossing            | 22 lines; est. 110 m total        | 2     |

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| Marking Type                    | Specification                                  | Quantity / Extent                                            | Phase |
|---------------------------------|------------------------------------------------|--------------------------------------------------------------|-------|
| Yellow kerb — No Parking        | Yellow thermoplastic; 100 mm wide on kerb face | Both sides, 25 m each side of 5 gates = 500 m total          | 1     |
| Diagonal hatching — No Stopping | Yellow thermoplastic; 150 mm diagonal stripes  | School gate forecourts and P/D bays; est. 200 m <sup>2</sup> | 2     |
| Cycle lane edge line            | White thermoplastic; 150 mm; continuous        | 650 m cycling corridor; 1,300 m total                        | 3     |
| Cycle pictogram                 | Green thermoplastic; 1,200 mm bicycle symbol   | 32 pictograms at 20 m intervals along corridor               | 3     |

### 4.5.5 Traffic Regulation Orders

Traffic Regulation Orders (TROs), issued under the Motor Vehicles Act 1988 as amended in 2019, give legal force to the speed limits and parking restrictions proposed for the school zone. Without TROs, the signage and markings have persuasive value but limited legal backing; with TROs, violations are enforceable offences attracting penalties under the Act. Table 4.20 lists the six TROs proposed for the precinct, with their legal provisions and priority.

**Table 4.20:** Proposed Traffic Regulation Orders

*Note. Issued by SP (Traffic), Bhopal in coordination with BMC Commissioner, under MV Act 1988/2019.*

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| TRO No. | Subject                         | Legal Authority                       | Operating Hours                            | Key Provision                                                                                          | Priority  |
|---------|---------------------------------|---------------------------------------|--------------------------------------------|--------------------------------------------------------------------------------------------------------|-----------|
| TRO-01  | School Zone Speed Limit         | MV Act S.112; MV Amendment 2019 S.43  | 7:00 AM–5:00 PM, school days               | Max. 25 kmph in SPZ; max. 30 kmph in STZ; all vehicle categories                                       | Immediate |
| TRO-02  | No Parking / No Stopping        | MV Act S.122                          | 7:00 AM–5:00 PM, school days               | No parking within 25 m of each school gate on both sides; no stopping on carriageway in front of gates | Immediate |
| TRO-03  | One-Way Circulation             | MV Act S.119                          | 7:30–8:45 AM and 1:45–3:30 PM, school days | Internal precinct access road designated one-way northbound during peak school hours                   | Phase 2   |
| TRO-04  | Heavy Vehicle Restriction       | MV Act S.115                          | 7:00–9:30 AM and 1:30–4:00 PM, school days | Vehicles > 3.5 t GVW prohibited on internal precinct roads during school peak hours                    | Phase 2   |
| TRO-05  | Vending Prohibition             | BMC Hawkers Policy 2019; MV Act S.115 | 7:00 AM–5:00 PM, school days               | No static vending within 15 m of school gates; alternative vending zones designated 100 m+ from gates  | Immediate |
| TRO-06  | Pick-up/Drop-off Bay Regulation | MV Act S.122                          | 7:30–9:00 AM and 1:30–4:00 PM, school days | Maximum 5-minute stopping in designated bays; towing authority for non-compliant vehicles              | Phase 2   |

### 4.5.6 CCTV Surveillance Network

An IP-based CCTV surveillance network of 18 cameras is proposed across the precinct, integrated with the Bhopal Smart City Integrated Command and Control Centre (ICCC).

As shown in Table 4.21, the network combines ANPR (Automatic Number Plate

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Recognition)-capable cameras at gateway approaches for automated speed and parking enforcement, with wide-angle dome cameras at school gate frontages and intersection overviews for incident detection and monitoring. The full camera location schedule is provided in Appendix A, Table A10.

ANPR cameras are connected to the e-challan automated penalty notice system, allowing speed violations captured on camera to trigger an automatic penalty notice to the registered vehicle owner without requiring a traffic officer to be physically present at the location. This has been shown in multiple Indian Smart City implementations (Pune, Surat, Indore) to achieve sustained compliance improvements where purely officer-dependent enforcement has failed.

**Table 4.21:** CCTV Network — Key Technical Parameters

*Note. Bhopal Smart City ICCC integration standard; data retention per IT Act 2000.*

| Parameter                    | Specification                                                                                                       |
|------------------------------|---------------------------------------------------------------------------------------------------------------------|
| Total cameras                | 18 IP cameras (4 ANPR-capable at gateways; 14 dome IP at gates and intersections)                                   |
| General camera specification | 4K resolution (8 MP) dome IP; 360° pan; IR night vision 30 m range; IP66 weatherproof                               |
| ANPR camera specification    | 2 MP minimum; dedicated illumination unit for plate capture; mounted on overhead gantry or cantilever arm           |
| e-challan integration        | ANPR output connected to MP e-challan system; cross-referenced with VAHAN database for vehicle owner identification |
| Recording                    | Continuous 24/7 recording; 30-day local NVR storage; 90-day cloud backup at ICCC                                    |

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| Parameter       | Specification                                                                                                                             |
|-----------------|-------------------------------------------------------------------------------------------------------------------------------------------|
| Live monitoring | Dedicated school zone tile on ICCC dashboard, active 7:00 AM–5:00 PM; automated alert on speed violation or pedestrian conflict detection |
| Public display  | Live feed monitor at each school's administration office — transparency and deterrence function                                           |
| Maintenance     | Annual ANPR calibration; monthly dome cleaning; BMC IT department responsible for network and server maintenance                          |

### 4.5.7 Traffic Police Deployment

Dedicated Traffic Police deployment at three priority intersections during school peak hours is proposed as the most immediately visible enforcement measure. Table 4.22 details the five deployment posts, the personnel requirement, and the primary functions at each. The deployment requires a formal order from SP (Traffic), Bhopal, designating these posts as mandatory school-hour deployment locations — a relatively straightforward administrative step that can be completed within Phase 1.

**Table 4.22:** Traffic Police Deployment Plan

*Note. To be formalised by SP (Traffic), Bhopal, under the School Zone Safety Committee framework.*

| Post  | Location                           | Morning Slot | Afternoon Slot | Personnel                      | Primary Functions                                                                                 |
|-------|------------------------------------|--------------|----------------|--------------------------------|---------------------------------------------------------------------------------------------------|
| TP-01 | Subhash Chowraha (raised junction) | 7:15–9:00 AM | 1:45–3:45 PM   | 1 constable + 1 head constable | Speed monitoring; pedestrian crossing management; pick-up/drop-off coordination; challan issuance |

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| Post                  | Location                       | Morning Slot | Afternoon Slot | Personnel                 | Primary Functions                                                                 |
|-----------------------|--------------------------------|--------------|----------------|---------------------------|-----------------------------------------------------------------------------------|
| TP-02                 | 7 Number Chowraha (LPI signal) | 7:30–9:00 AM | 1:45–3:30 PM   | 1 constable               | Signal phase management; pedestrian crossing supervision; turning vehicle control |
| TP-03                 | KV No. 2 link road junction    | 7:30–8:45 AM | 2:00–3:30 PM   | 1 constable               | Mini-roundabout management; school bus coordination                               |
| TP-04 (mobile patrol) | Link Road No. 2 SPZ segment    | 7:00–9:30 AM | 1:30–4:00 PM   | 1 constable on motorcycle | Speed enforcement (handheld laser gun); TRO-01/TRO-02 challan issuance            |
| TP-05 (ICCC)          | Traffic Control Room, Bhopal   | 7:00–9:30 AM | 1:30–4:00 PM   | 1 operator (designated)   | CCTV / ANPR monitoring; alert dispatch; incident coordination                     |

### 4.5.8 School Zone Safety Warden Programme

Safety Wardens are trained community volunteers who provide a visible, human presence at each school gate frontage during peak hours, supplementing the police deployment at the three intersection nodes. Ten wardens are proposed — two per school gate (one male, one female) — recruited from the parent community and local residents through Parent-Teacher Associations.

Each warden is trained annually by SP (Traffic), Bhopal, in a 3-hour session covering traffic management hand signals, pedestrian crossing supervision, school zone rules, and emergency procedures. Wardens are equipped by BMC with a high-visibility orange vest ('SCHOOL SAFETY WARDEN — [School Name]'), a whistle, and a STOP/GO lollipop

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sign (IRC:67 compliant, minimum 450 mm diameter). Wardens operate during the same hours as the Traffic Police deployment and maintain a daily incident log submitted to the School Zone Safety Committee. The programme draws directly on the model used in the New Delhi CROSSWALK initiative's 'Road Safety Clubs' and the 250 Metres of Happiness community stewardship structure (HumanQind, 2024).

## 4.6 Inclusive and Sustainable Approaches

### 4.6.1 Environmental Sustainability

#### 4.6.1.1 Staggered School Timings

The five institutions in the precinct currently operate on nearly identical schedules, concentrating all school-related vehicle movements into the same 30-minute arrival and departure windows. This creates both the highest congestion intensity and the highest vehicular emission exposure for children at precisely the moments they are present in the street environment. As shown in Table 4.23, a staggered timing scheme is proposed to distribute vehicle movements across a 90-minute window, reducing peak vehicle density in the school zone by an estimated 55–65% and providing Traffic Police deployment the ability to cover multiple school gates sequentially.

**Table 4.23:** Proposed Staggered School Timing Schedule

*Note. Implementation requires DEO Bhopal approval and SZSC facilitation.*

| Institution                            | Current Start | Current End | Proposed Start | Proposed End | Offset from KV Anchor      |
|----------------------------------------|---------------|-------------|----------------|--------------|----------------------------|
| Kendriya Vidyalaya No. 2               | 7:30 AM       | 2:00 PM     | 7:30 AM        | 2:00 PM      | Anchor (retained)          |
| Subhash Excellence Government HSS      | 7:30 AM       | 2:00 PM     | 7:50 AM        | 2:20 PM      | + 20 minutes               |
| Sarojini Naidu Government Girls HSS    | 7:30 AM       | 2:00 PM     | 8:10 AM        | 2:45 PM      | + 40 minutes               |
| Government Women's Polytechnic College | 8:30 AM       | 4:30 PM     | 8:30 AM        | 4:30 PM      | Retained (non-overlapping) |
| Nutan College                          | 9:00 AM       | 5:00 PM     | 9:00 AM        | 5:00 PM      | Retained (non-overlapping) |

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### 4.6.1.2 Green Buffer Strips

A 500–1,000 mm wide planted buffer strip is proposed between the carriageway edge and the footpath clear width throughout the School Proximal Zone. The buffer performs three simultaneous functions: it physically separates pedestrians from vehicles, providing a passive safety barrier; it intercepts airborne particulate matter (PM<sub>2.5</sub> and PM<sub>10</sub>) generated by vehicle engines and brake dust — studies from comparable urban environments indicate a 25–40% PM concentration reduction for pedestrians immediately behind a 1-metre vegetation buffer (reviewed in World Resources Institute India, 2021); and it reduces the thermal environment on the footpath through tree canopy shade during Bhopal's extreme summer months. Species selected for the buffer strips are locally appropriate, pollution-tolerant, and drought-resistant, consistent with Bhopal's semi-arid climate (approximately 1,100 mm mean annual rainfall, concentrated in June–September). As shown in Table 4.24, five planting zones are specified with different species profiles suited to their specific function and spatial context.

**Table 4.24:** Green Buffer Strip Planting Specification

*Note. Species selected per Bhopal Climate Zone (semi-arid, means annual rainfall 1,100 mm). BMC*

*Horticulture Department responsible for procurement and installation.*

| Location                    | Species                              | Mature Height    | Spacing         | Primary Function                                        |
|-----------------------------|--------------------------------------|------------------|-----------------|---------------------------------------------------------|
| Buffer strip — full SPZ     | Duranta erecta (Shehnai); Ixora spp. | 600–1,200 mm     | 0.5 m           | PM interception; physical vehicle-pedestrian separation |
| Gateway node kerb extension | Ficus microcarpa (Indian Laurel)     | 8–12 m (managed) | 1 per extension | Visual landmark; PM interception; shade                 |

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| Location                    | Species                                                        | Mature Height        | Spacing                     | Primary Function                                    |
|-----------------------------|----------------------------------------------------------------|----------------------|-----------------------------|-----------------------------------------------------|
| Walking route shading       | Peltophorum pterocarpum (Copper Pod); Cassia fistula (Amaltas) | 12–18 m              | 8 m spacing                 | Summer shade; seasonal street identity              |
| School gate forecourt       | Plumeria obtusa; Bauhinia variegata                            | 4–8 m                | 1 per 6 m at forecourt edge | Shade for waiting parents; aesthetic                |
| Pick-up/drop-off bay marker | Phoenix sylvestris (Wild Date Palm)                            | 4–10 m (single stem) | 1 per bay end               | Vertical marker; minimal footprint; low maintenance |

### 4.6.1.3 Climate-Resilient Infrastructure

All proposed infrastructure is designed to perform under Bhopal's climate conditions — principally the concentrated monsoon rainfall of 650–750 mm in June–September and the summer temperatures of 40–44°C in April–June. The following climate-resilience principles are embedded in all proposals: (a) All footpath surfaces have a 2.5% cross-fall toward perimeter drainage channels, preventing ponding during heavy rainfall; (b) raised crossing designs incorporate perimeter V-channels (150 × 150 mm) to prevent platform flooding; (c) all sheltered structures (gate canopies, WSB stops, parent waiting areas) have a minimum 600 mm roof overhang on the south-west exposure to provide shade during peak solar radiation hours; (d) all thermoplastic road markings are specified with UV-resistant compound to prevent premature fading in summer conditions; and (e) planted buffer strips incorporate bio-swale sections at low points capable of detaining first-flush monsoon runoff and filtering road surface pollutants before discharge to municipal drainage.

### 4.6.2 Road Safety Education

#### 4.6.2.1 Structured Road Safety Curriculum

No structured road safety education programme exists at any of the five study area institutions. This is consistent with the finding of WRI India (2021) that school-based road safety education in India is 'largely ad hoc, dependent on individual teacher initiative, and absent from the formal curriculum in most government schools.' A structured, age-differentiated road safety curriculum is proposed for integration into the formal school programme of all five institutions, aligned with the National Road Safety Policy 2010's mandate for road safety education in schools.

As shown in Table 4.25, the curriculum is structured across four class levels, each with age-appropriate content, teaching methods, and assessment forms. The curriculum is delivered in Hindi (primary medium, with English-medium option for Kendriya Vidyalaya), through existing subject periods (EVS/social science/physical education), and through Road Safety Club activities. Teaching materials — workbooks, visual aids, posters, and short video content — are proposed to be developed in collaboration with the Madhya Pradesh Road Safety Cell and WRI India.

**Table 4.25:** Road Safety Curriculum — Summary by Class Level

*Note. Aligned with National Road Safety Policy 2010 and MoRTH road safety education guidelines.*

| Class Level       | Age     | Time Allocation    | Core Content                                                                | Teaching Method                   | Assessment                              |
|-------------------|---------|--------------------|-----------------------------------------------------------------------------|-----------------------------------|-----------------------------------------|
| Primary (Cl. 1–3) | 5–8 yrs | 30 min/week in EVS | Basic signs (STOP, GO, Pedestrian Crossing); rules for crossing; staying on | Story-based learning; flashcards; | End-of-term oral quiz; safety awareness |

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| Class Level                          | Age        | Time Allocation                             | Core Content                                                                                                                                                  | Teaching Method                                                                                                                                | Assessment                                                                                          |
|--------------------------------------|------------|---------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------|
|                                      |            |                                             | footpath; trusted adult guidance near roads                                                                                                                   | colouring activities; role-play                                                                                                                | drawing competition                                                                                 |
| Upper Primary (Cl. 4–6)              | 9–11 yrs   | 45 min/week in Social Science               | All school zone signs; pedestrian rights; safe cycling basics; traffic signals; road accident first response                                                  | Interactive route-mapping activity (draw your journey + mark hazards); field observation of school zone; cycle safety workshop                 | Route safety map submission; peer teaching (one student explains one sign to class)                 |
| Secondary (Cl. 7–9)                  | 12–14 yrs  | 45 min per fortnight + project              | MV Act basics; school zone design principles; speed and stopping distance; GIS conflict mapping (computer activity); Road Safety Club participation           | Field audit using simplified IRC:SP:32 checklist; guest lecture from BMC / Traffic Police; road safety debate                                  | Safety audit group report; RSC active membership as activity credit                                 |
| Sr. Secondary / Diploma (Cl. 10–12+) | 15–18+ yrs | 1 period per fortnight in Civics / Elective | Road accident data analysis; urban planning and school zone design; Vision Zero and Decade of Action; community leadership; student zone improvement proposal | Case study analysis (Bengaluru, Delhi, NYC — from Chapter 2); student-designed improvement proposal for one zone feature; presentation to SZSC | Student improvement proposal document; panel evaluation including BMC officer; RSC leadership track |

### 4.6.2.2 Road Safety Clubs

Road Safety Clubs (RSCs) are proposed at each of the five institutions, modelled on the successful YCARS programme in Bengaluru (Concern for Road and Pedestrian Safety, 2020) and the student Safety Clubs of the New Delhi CROSSWALK initiative

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(HumanQind, 2024). Each RSC consists of 15–20 student members (Classes 7–12 or equivalent), an elected president, and a teacher faculty in-charge. RSC activities are summarised in Table 4.26.

**Table 4.26:** Road Safety Club (RSC) Programme — Summary of Activities

*Note. Annual cycle aligned with the academic year. Programme coordination through SZSC.*

| Activity                        | Description                                                                                                                                                       | Frequency                                  | Responsible                                      |
|---------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------|--------------------------------------------------|
| Annual safety audit walk        | IRC:SP:32-aligned audit of school zone using simplified student checklist; findings mapped and submitted to SZSC                                                  | Once per academic year (beginning of term) | RSC + Faculty in-charge + BMC representative     |
| Safety incident log             | Daily record of near-miss events, infrastructure damage, parking violations; submitted monthly to School Safety Team                                              | Daily observation; monthly submission      | RSC President                                    |
| Road safety awareness campaign  | Annual road safety week (January — National Road Safety Month): poster competition, assembly presentation, street play at school gate, parent information session | Once per year                              | RSC + School Principal + BMC Road Safety Officer |
| Student mural programme         | Students design and paint a road safety mural on the precinct boundary wall allocated to their school (theme: 'Our Safer School Journey')                         | Once (permanent); refreshed every 3 years  | RSC Art Committee + BMC Urban Art Cell           |
| Walking School Bus ambassadors  | RSC members serve as walking ambassadors on the WSB route associated with their school (one member per route per direction)                                       | Daily during school days                   | RSC; WSB Supervisor                              |
| SZSC annual report presentation | RSC President presents annual safety audit findings and RSC                                                                                                       | Once per year                              | RSC President; SZSC Chairperson                  |

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| Activity                 | Description                                                                                                                  | Frequency     | Responsible                                      |
|--------------------------|------------------------------------------------------------------------------------------------------------------------------|---------------|--------------------------------------------------|
|                          | activity report at the SZSC Annual Review Meeting                                                                            |               |                                                  |
| Inter-school safety quiz | Annual inter-school road safety quiz among five precinct institutions; prize: 'School Safety Trophy' presented at Annual Day | Once per year | BMC Road Safety Officer; SZSC; School Principals |

### 4.6.2.3 Parent Orientation and Engagement

Survey data shows that 38.2% of students commute with family members, making parental behaviour at school gates a critical safety variable. A structured parent engagement programme addresses this through education:

- Annual mandatory road safety orientation is integrated into the start-of-year Parent-Teacher Meeting at all five schools, covering safe drop-off procedures, pick-up/drop-off bay operation, TRO content, and WSB programme introduction.
- A 'Safe School Commute Guide' — a two-page illustrated guide in Hindi (and English for KV No. 2) — is distributed to all parents at the beginning of each academic year. The guide covers safe routes, school zone rules, bay operation, and WSB schedule, and is designed with simple visuals accessible to parents of varying literacy levels.
- A WhatsApp group per school gate bay, managed by a Parent-Teacher Association volunteer, provides real-time communication of circulation updates and safety advisories. BMC Road Safety Officer participates as an observer.
- An annual 'Walk to School Day' — held on the 5th of January (National Road Safety Month) — involves all students, teachers, and invited parents walking the designated safe routes together. Media coverage organised by BMC amplifies the event's community impact.

### 4.6.3 Social Inclusivity

#### 4.6.3.1 Gender-Responsive Design

With 84% of survey respondents being female, the proposals incorporate specific gender-responsive design features throughout. Uniform and well-distributed street lighting along all walking routes — particularly Routes W1, W2, and W4, which pass through less-trafficked residential areas — addresses the compound fear of crime and traffic that female

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students experience disproportionately in low-light conditions. All waiting areas at school gates and WSB stops are designed to be fully enclosed, clearly visible, and free from concealed corners. Cycle parking at school gates is located within the CCTV-covered, supervised school frontage area. WSB supervisors include both male and female volunteers on each route.

### *4.6.3.2 Universal Accessibility*

Universal accessibility is achieved throughout the proposals through: 44 kerb ramps (1:12 gradient, 1.2 m minimum width) at all crossing approach points; blister-pattern tactile paving at all kerb ramp transitions and crossing approaches for the visually impaired; accessible push-button pedestrian signal units (900–1,000 mm height) at the 7 Number Chowraha LPI signal; minimum 1.8 m clear footpath width in the SPZ allowing comfortable passage of a wheelchair user alongside a pedestrian; and drinking water points at school gate waiting areas and the auto-rickshaw staging area.

### *4.6.3.3 Equitable Investment*

All five institutions — regardless of institutional category, school management type, or catchment socio-economic profile — receive the same standard of infrastructure improvement, signage, educational programming, and Safety Warden provision. This equity-of-provision principle is central to the precinct approach and distinguishes it from the typical Indian pattern of school zone improvement, which tends to concentrate on schools with influential management or access to CSR funding. A small RSC scholarship fund (Rs. 5,000 per school per year, funded through the SZSC annual budget) covers activity costs for RSC members from low-income households, removing economic barriers to participation.

## 4.7 Phased Implementation Plan

The proposals are structured in three implementation phases, calibrated by urgency, capital requirement, and institutional readiness. The phasing logic follows the principle that high-impact, low-cost measures should be implemented first to generate visible safety improvements, build community confidence, and create the institutional momentum necessary for the larger capital-intensive Phase 2 programme.

**Table 4.27:** Phased Implementation Plan — Summary

*Note. All costs are indicative estimates based on Schedule of Rates, Madhya Pradesh PWD 2023–24, and BMC standard rates for road and pedestrian works.*

| Phase                       | Timeline       | Focus                                                                  | Estimated Cost | Primary Deliverables                                                                                                                                                                                                                                                                                                                                                 |
|-----------------------------|----------------|------------------------------------------------------------------------|----------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Phase 1<br>—<br>Immediate   | Months<br>1–3  | Regulatory,<br>signage, markings,<br>community<br>mobilisation         |                | W-39 + R-25 signs on all approaches; 'SCHOOL ZONE' and 'SLOW' markings; no-parking kerb lines; TRO-01 and TRO-02 issued; Traffic Police deployment at 3 intersections; encroachment clearance; Safety Warden kits; SZSC constituted; Road Safety Clubs launched at 5 schools; parent orientation                                                                     |
| Phase 2<br>—<br>Medium-Term | Months<br>4–12 | Core engineering<br>— raised<br>crossings,<br>footpaths, bays,<br>CCTV |                | 9 raised table-top crossings; 2,100 m footpath construction/restoration; 44 kerb ramps; 8 zebra crossings; 3 pedestrian refuge islands; guard rails at school frontages; 5 pick-up/drop-off bays; auto-rickshaw staging area; 18-camera CCTV network (ICCC-integrated); kerb extensions at 4 gateways; 12 speed humps; green buffer planting; gate canopy structures |

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| Phase                  | Timeline | Focus                                                         | Estimated Cost | Primary Deliverables                                                                                                                                                                                                                                                                                   |
|------------------------|----------|---------------------------------------------------------------|----------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Phase 3<br>— Long-Term | Year 2   | SAZ improvements, education integration, cycling, replication |                | 650 m cycling corridor with parking; 4 safe walking routes (W1–W4) completed; LPI signal (7 Number Chowraha); road safety curriculum adopted in all 5 schools; staggered school timings implemented; Annual School Zone Safety Report published; replication planning for 3 additional Bhopal clusters |

**Table 4.28:** Financing Strategy — Funding Sources by Component

*Note. Sources confirmed as eligible through review of AMRUT 2.0, Smart Cities Mission, and MP Road Safety Fund guidelines.*

| Funding Source                                                              | Phase             | Eligible Components                                                                                    | Indicative Contribution |
|-----------------------------------------------------------------------------|-------------------|--------------------------------------------------------------------------------------------------------|-------------------------|
| Bhopal Municipal Corporation Annual Development Plan (ADP) — Capital Budget | Phase 2 primary   | Footpath construction, raised crossings, pick-up/drop-off bays, kerb extensions, guard rails, bollards |                         |
| AMRUT 2.0 (State allocation to BMC)                                         | Phase 2 + Phase 3 | Street lighting, cycling corridor, safe walking routes, green buffer development                       |                         |
| Bhopal Smart City Limited (BSCL)                                            | Phase 2           | CCTV surveillance network, ICCC integration, smart junction signal at 7 Number Chowraha                |                         |
| Madhya Pradesh State Road Safety Fund (MV Act 2019)                         | Phase 1 primary   | Signage, pavement markings, Safety Warden equipment, enforcement infrastructure                        |                         |

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| Funding Source                         | Phase                             | Eligible Components                                                                 | Indicative Contribution |
|----------------------------------------|-----------------------------------|-------------------------------------------------------------------------------------|-------------------------|
| CSR Funding (Local corporate partners) | Phase 1 +<br>Phase 2 +<br>ongoing | Road Safety Club materials, student murals, gate canopies, WSB programme management |                         |
| School Administration / DEO, MP        | Phase 2 +<br>ongoing              | Curriculum integration, teacher training, RSC activity costs, parent guide printing |                         |
| Auto-rickshaw staging user fee         | Phase 3 +<br>ongoing              | Staging area maintenance, EV charging infrastructure, WSB operational costs         |                         |

The total indicative implementation cost across all three phases is Rs. 2.03–2.47 Crore (approximately Rs. 20–25 million). This is within the scale of typical BMC ward-level capital projects and is fundable through the combination of sources identified in Table 4.28 without requiring any single source to bear the full cost.

## 4.8 Governance Structure and Monitoring Framework

### 4.8.1 School Zone Safety Committee

A School Zone Safety Committee (SZSC) for the Shivaji Nagar Safe School Precinct is proposed as the permanent, inter-agency coordinating and monitoring body for the programme. The SZSC is constituted by formal order of the BMC Commissioner and draws together all agencies with jurisdiction, authority, or stake in school zone safety outcomes. As shown in Table 4.29, the SZSC has ten members drawn from municipal, police, education, and community sectors.

**Table 4.29:** School Zone Safety Committee — Composition and Roles

*Note. Constituted by order of BMC Commissioner. Meets quarterly; annual review meeting each January.*

| Member           | Organisation                                  | Primary Role in SZSC                                                                                        |
|------------------|-----------------------------------------------|-------------------------------------------------------------------------------------------------------------|
| Chairperson      | Additional Commissioner, BMC (Transport Cell) | Overall coordination; financial approval; direction of BMC engineering and Zone office                      |
| Member Secretary | Road Safety Officer, BMC Zone 4               | Administrative coordination; meeting management; annual report preparation; day-to-day inter-agency liaison |
| Member           | SP (Traffic), Bhopal (or DSP Traffic)         | Enforcement: TRO issuance; Police deployment; CCTV/ANPR data; e-challan reporting                           |
| Member           | Executive Engineer (Roads), BMC PWD           | Infrastructure execution; drawing approval; maintenance contract management                                 |
| Member           | CEO, Bhopal Smart City Limited (or nominee)   | CCTV infrastructure; ICCV integration; digital safety systems                                               |

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| Member            | Organisation                                                    | Primary Role in SZSC                                                              |
|-------------------|-----------------------------------------------------------------|-----------------------------------------------------------------------------------|
| Member (rotating) | Principal representative — one of five institutions per quarter | School-level coordination; RSC linkage; schedule; parent engagement               |
| Member            | President, Shivaji Nagar PTA Federation                         | Community representation; WSB programme; parent orientation feedback              |
| Member            | District Education Officer (DEO), Bhopal                        | Curriculum integration approval; teacher training; staggered timing authorisation |
| Member            | Regional Transport Officer (RTO), Bhopal                        | Auto-rickshaw regulation; EV transition; school vehicle registration              |
| Observer          | WRI India or designated NGO safety partner (if applicable)      | Technical assistance; M&E support; best practice; funding facilitation            |

### 4.8.2 Monitoring and Evaluation Framework

The monitoring framework is built around 12 Key Performance Indicators (KPIs), covering outcomes under all four research objectives. As shown in Table 4.30, each KPI has a quantified baseline (from the Chapter 3 field survey and audit), a Year 1 target, and a Year 3 target. The primary data collection methods are: annual repeat questionnaire survey (n > 200) for perception and mode share data; bi-annual spot speed studies at three SPZ locations using laser measurement equipment; annual infrastructure compliance audit against IRC:SP:32-2023 parameters; and monthly CCTV/ANPR data analysis for vehicle speed and parking compliance.

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The SZSC publishes an Annual School Zone Safety Report in January each year, presenting the KPI data for the preceding academic year, the infrastructure audit findings from the annual safety walk, and the Road Safety Club activities of all five institutions. The report is submitted to the BMC Commissioner, the SP (Traffic), and the DEO, and is made available to the public through BMC's website. This transparency mechanism provides public accountability and enables longitudinal tracking of programme outcomes.

**Table 4.30:** Monitoring and Evaluation — Key Performance Indicators

*Note. Baseline from Chapter 3 field survey and audit, 2025–26. KPI measurement by SZSC Road Safety Officer.*

| KPI                                               | Linked Objective | Baseline                                  | Year 1 Target | Year 3 Target   | Measurement Method                                   |
|---------------------------------------------------|------------------|-------------------------------------------|---------------|-----------------|------------------------------------------------------|
| Mean vehicle speed within SPZ (kmph)              | 4.2.1            | Estimated > 45 kmph (perceptual baseline) | < 32 kmph     | < 27 kmph       | Laser spot speed study at 3 SPZ locations; bi-annual |
| % vehicles exceeding 25 kmph in SPZ               | 4.2.1            | Estimated > 90%                           | < 40%         | < 15%           | CCTV-ANPR data; monthly                              |
| % school gates with IRC-compliant raised crossing | 4.2.1            | 0% (0 of 5)                               | 100% (5 of 5) | 100% maintained | Annual infrastructure audit                          |
| Continuous footpath coverage in SPZ (%)           | 4.2.2            | ~40% (field estimate)                     | 85%           | 100%            | GIS measurement from field survey; annual            |
| % students walking or cycling to school           | 4.2.2            | 32.8% (survey, walk +                     | ≥ 40%         | ≥ 50%           | Annual mode share survey                             |

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| KPI                                                             | Linked Objective | Baseline        | Year 1 Target      | Year 3 Target                   | Measurement Method                             |
|-----------------------------------------------------------------|------------------|-----------------|--------------------|---------------------------------|------------------------------------------------|
|                                                                 |                  | cycle combined) |                    |                                 |                                                |
| % respondents experiencing/witnessing road accidents            | 4.2.1 + 4.2.2    | 34.6% (survey)  | < 25%              | < 10%                           | Annual repeat survey                           |
| % students rating school zone as 'safe' or 'very safe'          | 4.2.2            | ~15% estimate   | ≥ 35%              | ≥ 65%                           | Annual repeat perception survey                |
| % SPZ approaches with complete IRC:SP:32 sign + marking package | 4.2.3            | 0% (0 of 4)     | 100% (4 of 4)      | 100% maintained                 | Annual infrastructure audit                    |
| TRO-01 parking violation compliance at school gates             | 4.2.3            | ~5% estimated   | ≥ 50%              | ≥ 80%                           | Traffic Police monthly challan data + CCTV     |
| CCTV network operational and ICCC-integrated                    | 4.2.3            | Not present     | 100% (18 of 18)    | Maintained                      | ICCC monthly uptime report                     |
| Road Safety Clubs active at all 5 schools                       | 4.2.4            | 0 clubs         | 5 of 5 operational | 5 of 5 + annual audit completed | School records; SZSC annual report             |
| Annual parent orientation conducted at all 5 schools            | 4.2.4            | Not conducted   | 5 of 5 schools     | 5 of 5 annually                 | SZSC meeting minutes; PTA attendance registers |

### 4.8.3 Replication Framework

The Shivaji Nagar Safe School Precinct programme is explicitly designed as a replicable model for other school clusters in Bhopal and for comparable medium-sized Indian cities. Three additional school clusters in Bhopal meet the proposed replication criteria (presence

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of two or more schools within 300 m; combined enrolment > 1,000; located on a collector or sub-arterial road; documented IRC non-compliance): the Habibganj–Arera Colony cluster, the Shahpura cluster, and the MP Nagar cluster. Preliminary IRC:SP:32 compliance audits of these three clusters are proposed as a Phase 3 activity.

The SZSC is further proposed to develop a publicly available 'Safe School Precinct Implementation Toolkit' comprising: a simplified IRC:SP:32 audit checklist (in both professional and student-usable versions); standard drawings for raised crossings, footpaths, pick-up/drop-off bays, and signage; a SZSC constitution template; an RSC programme guide; and a Safe School Commute Guide template in Hindi. The toolkit would be available for download through BMC's website, enabling self-replication by any school cluster in Madhya Pradesh.

## 4.9 Final Proposal Drawings

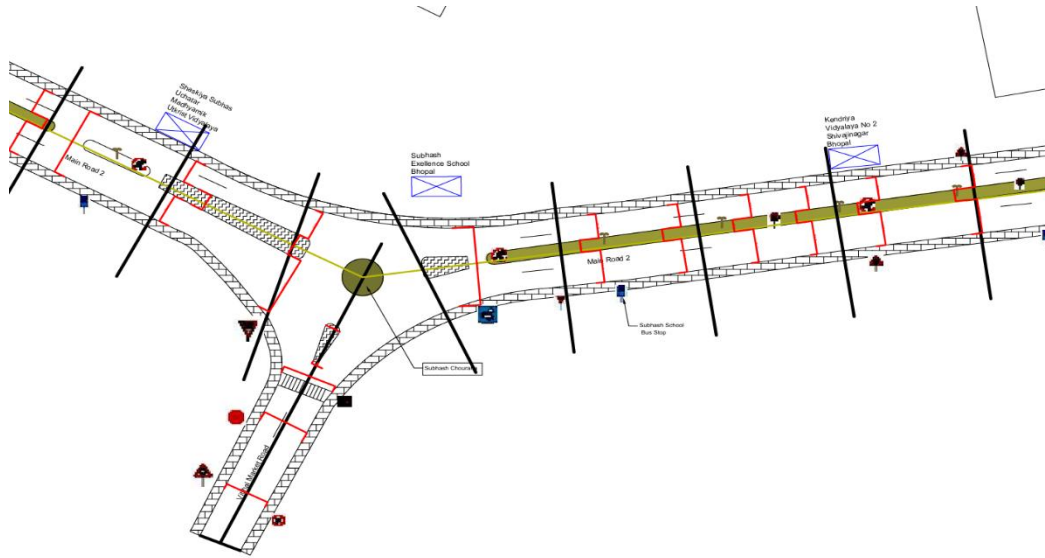


Fig. No.22 **Existing** AutoCAD Drawing

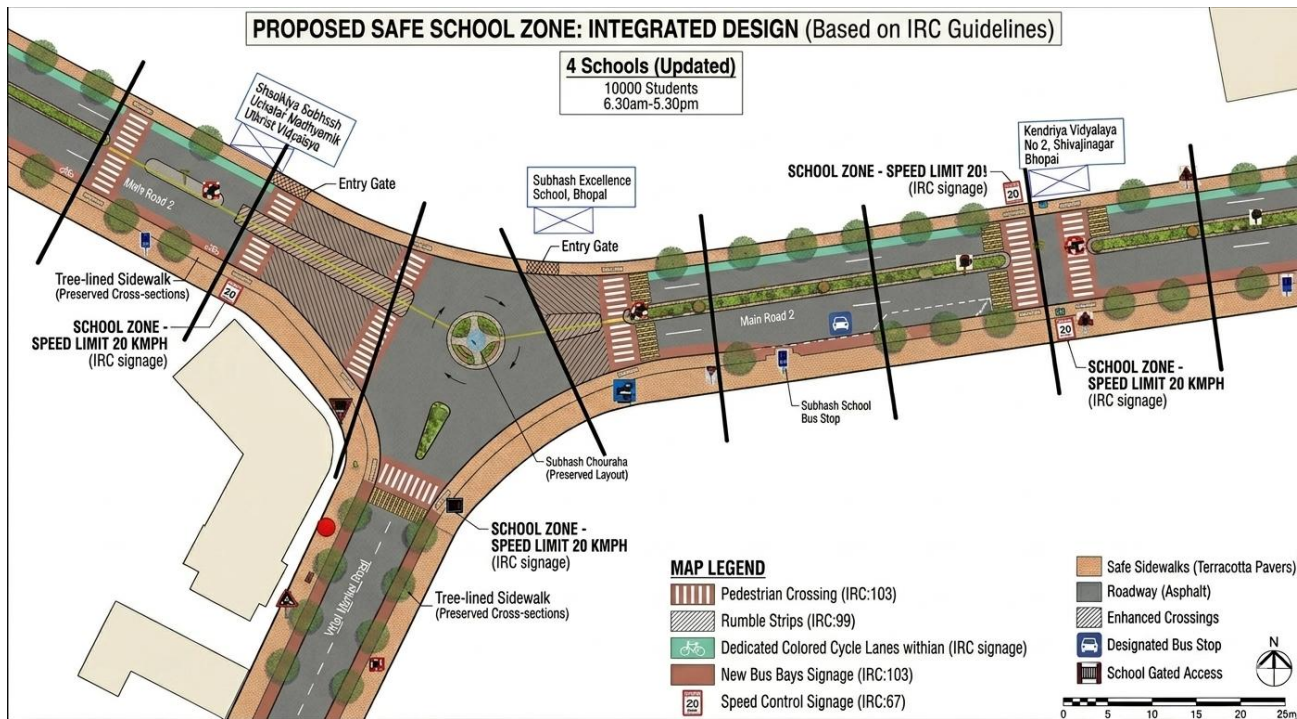


Fig. No.23 **Proposal**

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The existing school zone environment is characterized by unsafe pedestrian movement, lack of cycling infrastructure, and congestion caused by poorly designed bus stops. The proposed interventions aim to transform this unsafe environment into a safe, pedestrian-friendly, and traffic-efficient zone.

**Sidewalks:** Currently discontinuous, forcing pedestrians onto the carriageway. The proposal introduces continuous, tree-lined sidewalks that provide safety, shade, and comfort, encouraging walking as a primary mode of access.

**Pedestrian Crossings:** Few and unsafe crossings exist today. The proposal recommends multiple enhanced crossings with raised platforms, clear markings, and adequate lighting to prioritize pedestrian safety.

**Cycle Lanes:** No infrastructure exists for cyclists. Dedicated, colored cycle lanes are proposed to promote sustainable mobility and reduce vehicular congestion.

**Bus Stop Design:** Existing bus stops are on-road, obstructing traffic flow. The proposal introduces separate bus bays to streamline traffic and improve safety during boarding and alighting.

**Speed Control:** Absent in the current design. A strict 20 kmph speed limit, enforced through rumble strips and speed-calming devices, is proposed to reduce accident risk.

**Safety Signage:** Minimal signage currently fails to guide road users. The proposal recommends IRC-compliant signage at strategic locations to standardize communication and improve awareness.

Collectively, these interventions enhance pedestrian safety, traffic efficiency, and sustainable mobility, aligning with national road safety guidelines.

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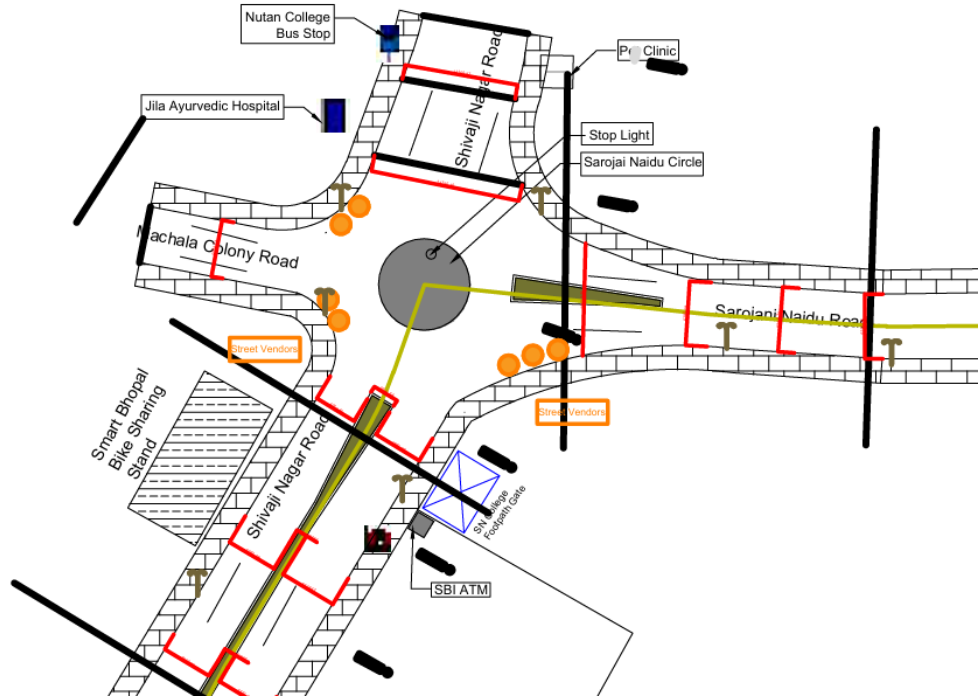


Fig. No.24 Existing - AutoCAD Drawing

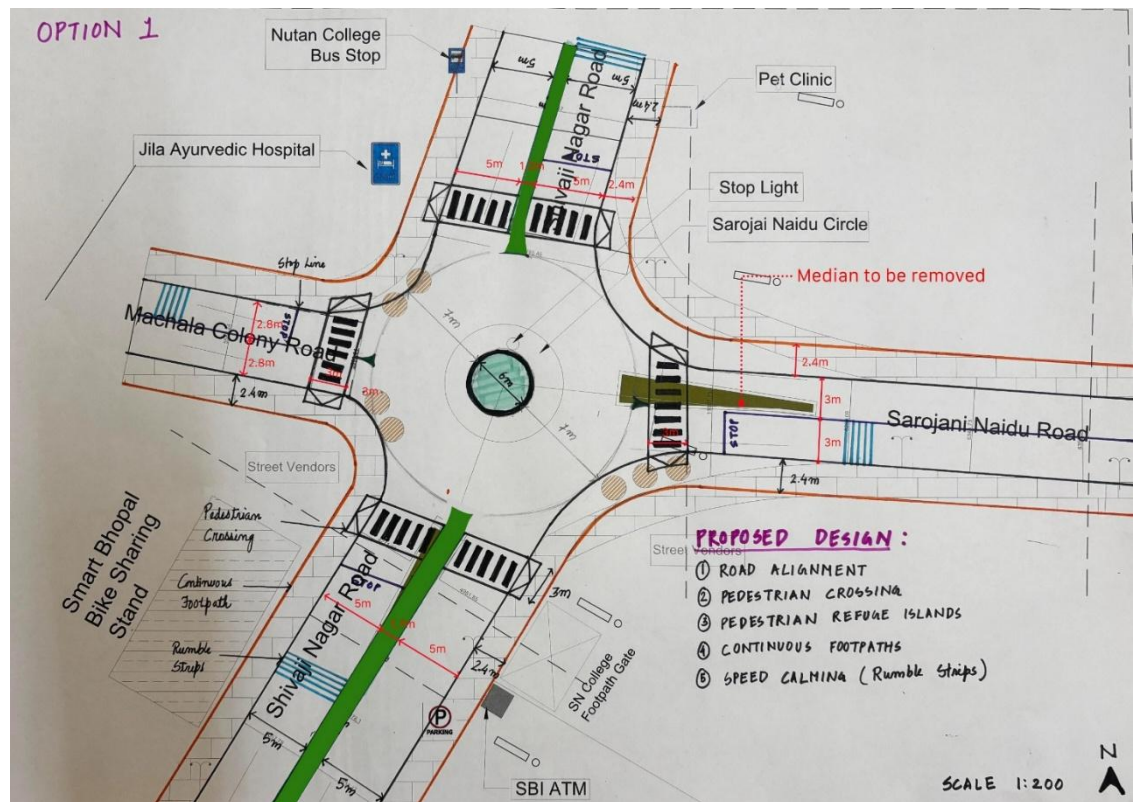


Fig. No.25 Proposal 1

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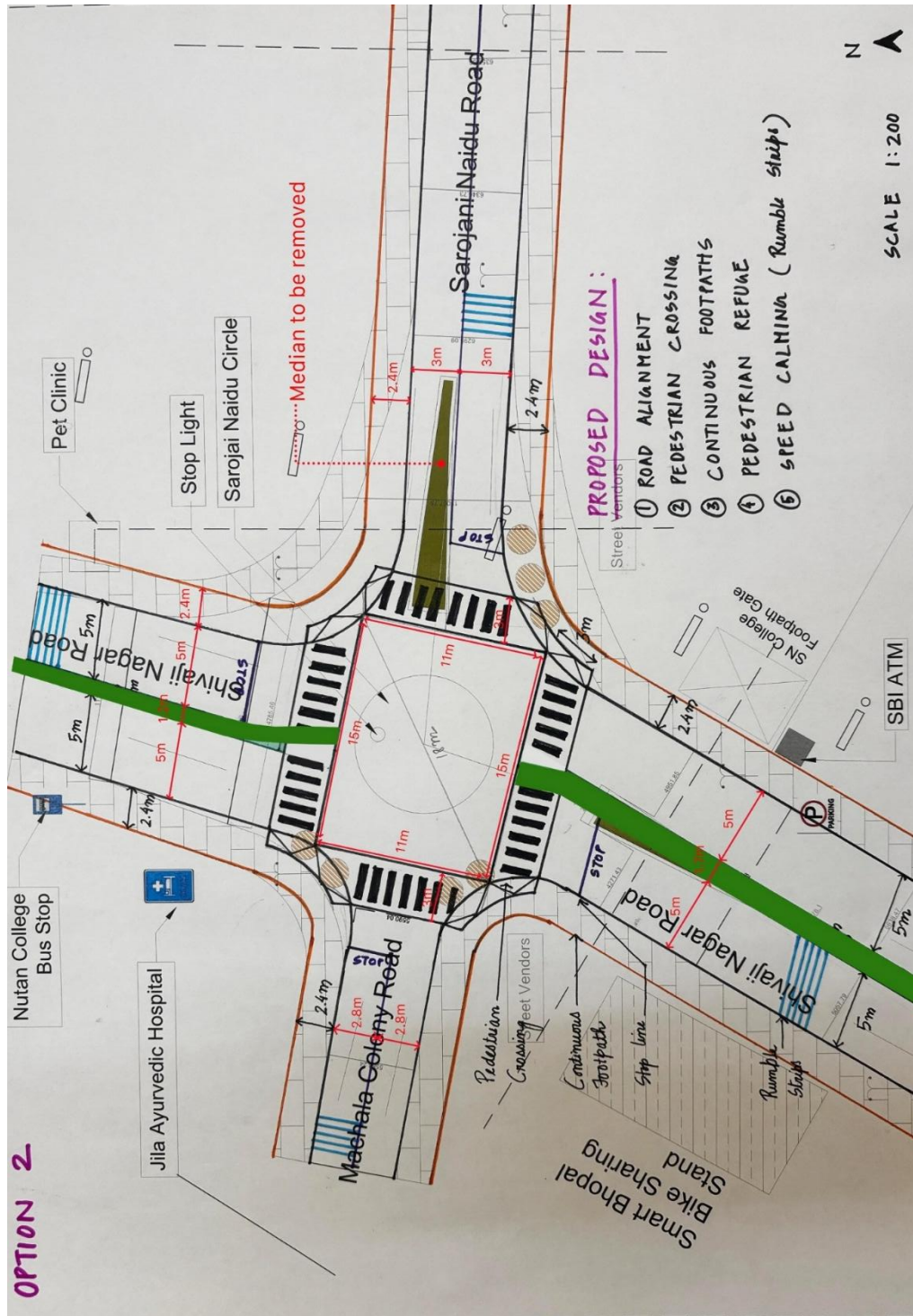


Fig. No.26 **Proposal 2**

A diagnostic assessment of the school zone reveals several infrastructural and operational shortcomings, including confusing road alignment and turning movements that create conflict points, unsafe and discontinuous pedestrian crossings, obstructive medians that hinder smooth traffic flow, congestion caused by street vendors and on-road bus stops, and the absence of continuous footpaths or safe pedestrian refuges that force pedestrians into unsafe road use. To address these issues, two intervention strategies are proposed. The first, a comprehensive intervention, incorporates multiple refuge islands, continuous footpaths, enhanced crossings, and speed-calming measures, representing a higher level of intervention that prioritizes pedestrian safety above traffic efficiency. While this option is suitable for long-term sustainability, it requires greater budget allocation and implementation effort. The second, a moderate intervention, focuses on basic improvements such as continuous footpaths and safer crossings, with fewer refuge islands and simpler speed-calming measures. This option balances safety with cost-effectiveness and is easier to implement within limited budgets and shorter timelines. The decision between these alternatives depends on budget availability, implementation feasibility, and the balance between pedestrian safety and traffic efficiency, with Option 1 maximizing safety and Option 2 offering a pragmatic, cost-effective solution.

### **Signage Proposal**

Signage is essential for ensuring safety in school zones by guiding drivers, cyclists, and pedestrians. At present, signage is minimal and inconsistent, leading to unsafe behavior and reduced awareness. The proposal introduces IRC-compliant signs placed strategically across the zone: speed limit signs at entry points, pedestrian crossing signs near designated crossings, “School Ahead” signs before entrances, bus bay signs at separate stops, and cycle lane signs along dedicated paths. These measures will improve driver compliance, enhance pedestrian safety, reduce congestion, and align the zone with national road safety standards.

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### Signages Placement

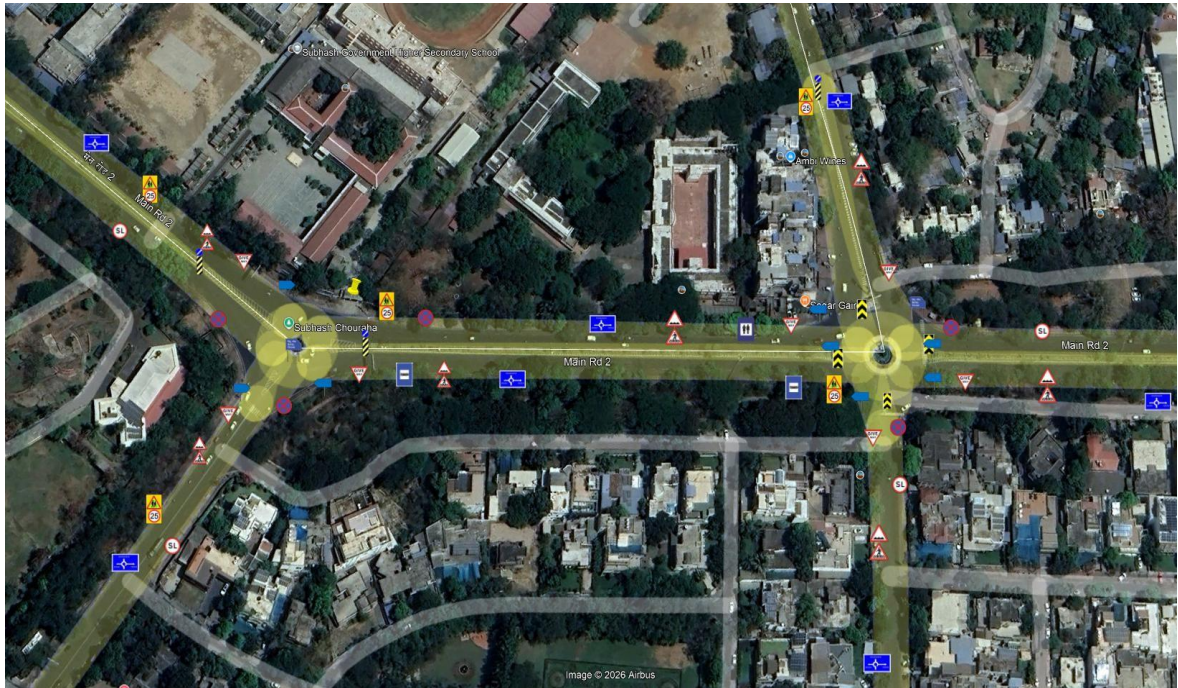


Fig. No.27 Signages Placement Proposal

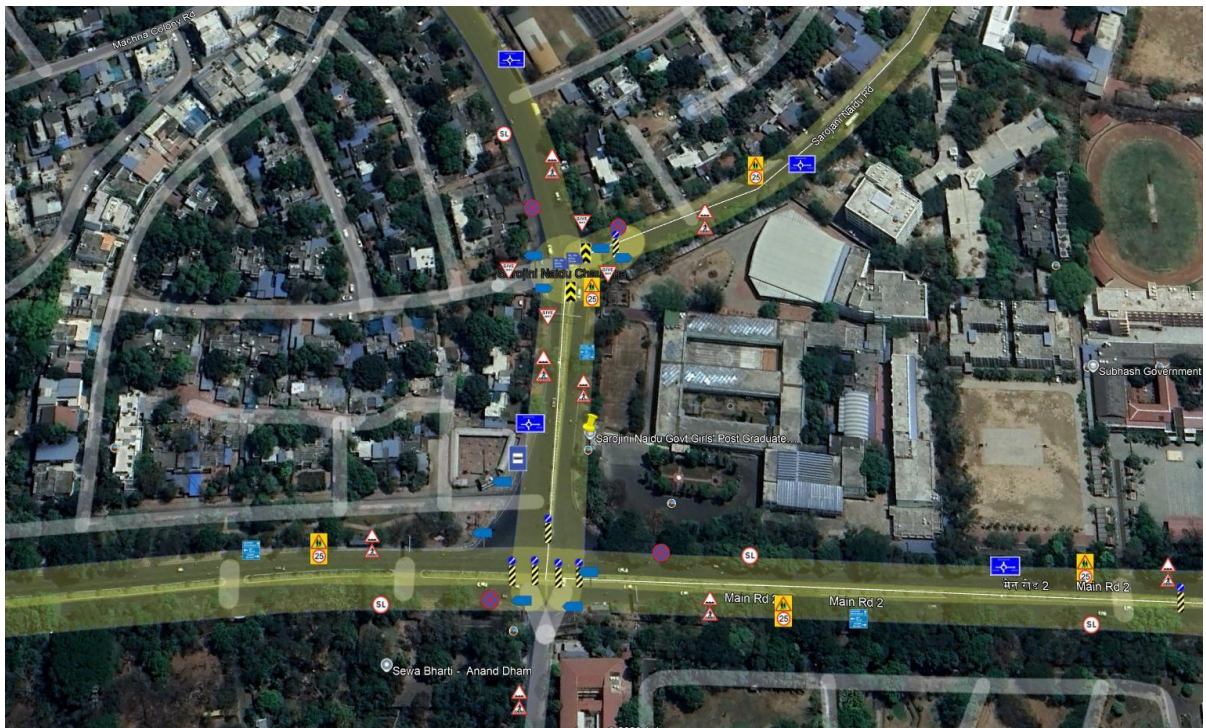


Fig. No.28 Signages Placement Proposal

## SCHOOL ZONE SAFETY

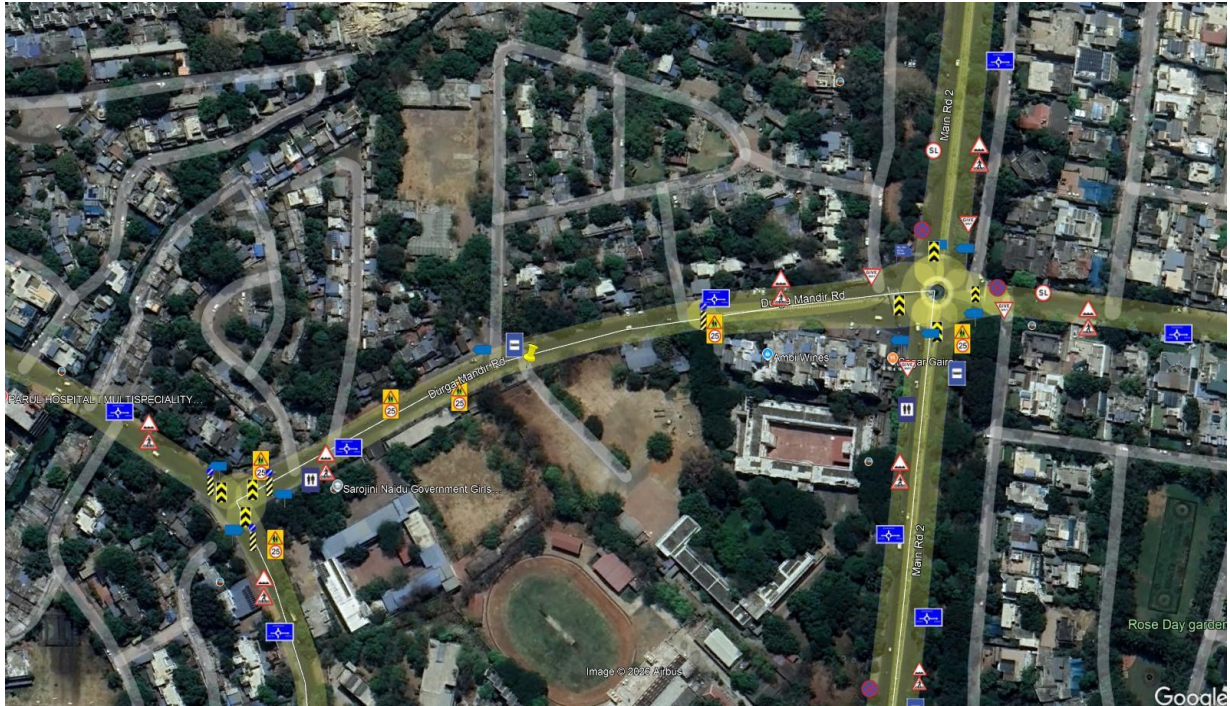


Fig. No.29 Signages Placement Proposal

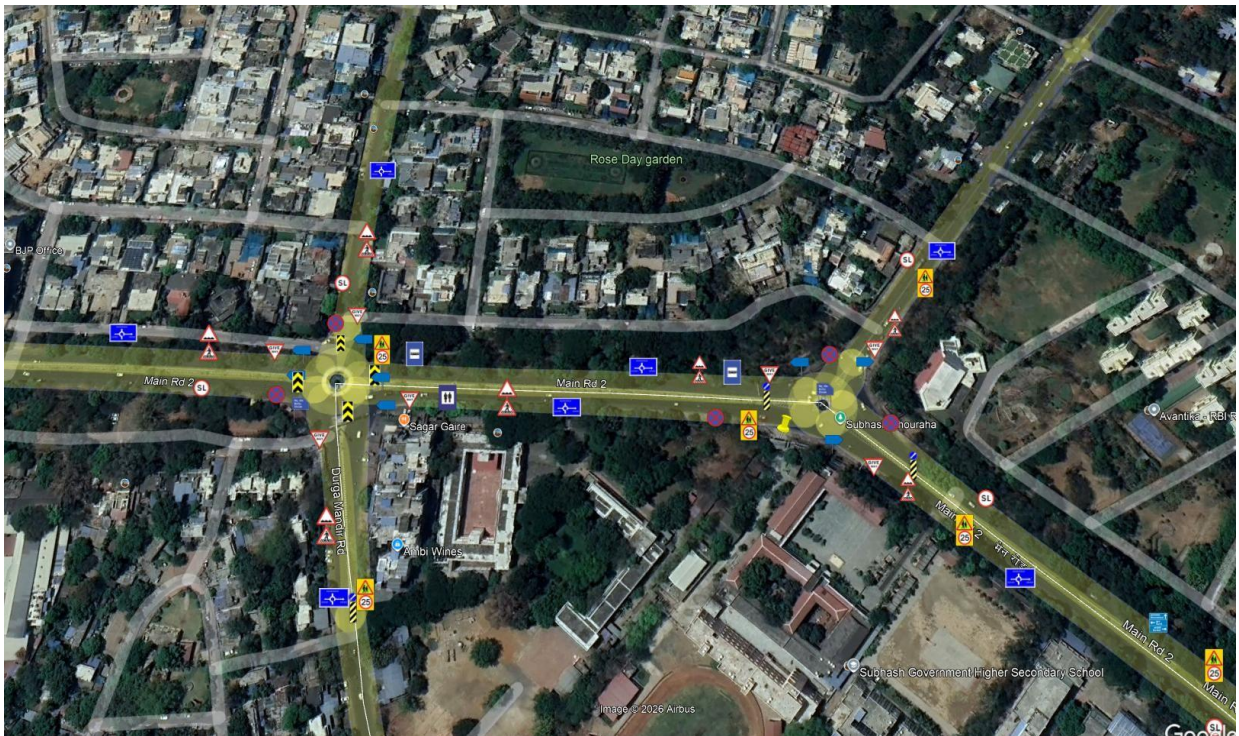


Fig. No.30 Signages Placement Proposal

### 4.10 Conclusion

This chapter has presented a comprehensive, objective-aligned set of planning proposals for the Shivaji Nagar Safe School Precinct in Bhopal. The proposals are organised around four research objectives: speed management and traffic calming (Objective 4.2.1); pedestrian and non-motorized infrastructure (Objective 4.2.2); school zone delineation and enforcement (Objective 4.2.3); and inclusive and sustainable approaches (Objective 4.2.4). Each proposal is traceable to a specific finding in the field analysis and to a specific provision in the IRC normative framework.

The physical interventions — nine raised crossings, 2,100 metres of continuous footpath, 22 zebra crossings, 44 kerb ramps, five pick-up/drop-off bays, four gateway treatments, twelve speed humps, and an 18-camera CCTV network — together transform the physical environment of the school zone from a high-risk, uncontrolled arterial fringe to a predictable, child-priority precinct. The complementary institutional and educational interventions — the School Zone Safety Committee, Traffic Regulation Orders, Safety Warden programme, Road Safety Clubs, and structured road safety curriculum — ensure that the physical improvements are enforced, maintained, and embedded in a lasting culture of community safety ownership.

The phased implementation plan demonstrates that the most critical safety improvements can begin within three months at a cost of approximately Rs. 8–12 Lakh (Phase 1), building to the full engineering programme over twelve months (Phase 2, Rs. 130–155 Lakh) and long-term sustainability investments over two years (Phase 3, Rs. 60–80 Lakh). The total indicative investment of Rs. 2.0–2.5 Crore is fundable through a combination of BMC

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capital budget, AMRUT 2.0, Smart Cities Mission, and MP State Road Safety Fund allocations.

Most fundamentally, the proposals prioritise the child as the primary user of the school zone — a principle consistently supported by both the IRC normative framework and the international evidence base reviewed in Chapter 2. The survey data from Chapter 3 shows that 96.6% of stakeholders agree that safety improvements are urgently needed. This chapter provides a detailed, feasible, and replicable response to that mandate.

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| S. No. | Source Type             | In-text Citation  | Full Reference                                                                                                                                                                                                                                                                                           |
|--------|-------------------------|-------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
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| S. No. | Source Type                     | In-text Citation               | Full Reference                                                                                                                                                                                                                                                                               |
|--------|---------------------------------|--------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
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| 20.    | Govt. Policy                    | (MoRTH, 2014)                  | Ministry of Road Transport and Highways (MoRTH) (2014), <i>National Urban Transport Policy (NUTP) 2014</i> , Ministry of Road Transport and Highways and Ministry of Urban Development, Government of India, New Delhi.                                                                      |
| 21.    | Govt. Report                    | (MoRTH, 2023)                  | Ministry of Road Transport and Highways (MoRTH) (2023), <i>Road Accidents in India 2022</i> , Transport Research Wing, Ministry of Road Transport and Highways, Government of India, New Delhi.                                                                                              |
| 22.    | Journal — More than two authors | (Muennig <i>et al.</i> , 2014) | Muennig P <i>et al.</i> (2014), <i>The cost-effectiveness of New York City's Safe Routes to School program</i> , American Journal of Public Health, Vol 104 No. 7, July 2014, pp1294–1299. <a href="https://doi.org/10.2105/AJPH.2014.301917">https://doi.org/10.2105/AJPH.2014.301917</a> . |

## SCHOOL ZONE SAFETY

| S. No. | Source Type                     | In-text Citation             | Full Reference                                                                                                                                                                                                                                                                                                     |
|--------|---------------------------------|------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 23.    | Journal — More than two authors | (Nanda <i>et al.</i> , 2018) | Nanda S <i>et al.</i> (2018), <i>Child road safety and injury vulnerability in India: Developmental and environmental risk factors</i> , Indian Journal of Community Medicine, Vol 43 No. 2, April–June 2018, pp112–118.                                                                                           |
| 24.    | E-Journal / Govt. Report        | (NHTSA, 2016)                | National Highway Traffic Safety Administration (NHTSA) (2016), <i>Safe Routes to School: National Overview and Evidence Review</i> , [ejournal]. United States Department of Transportation, Washington D.C. Retrieved from <a href="https://www.nhtsa.gov">https://www.nhtsa.gov</a> (Accessed on 20 March 2025). |
| 25.    | Technical Report                | (NYCDOT, 2013)               | New York City Department of Transportation (NYCDOT) (2013), <i>Safe Routes to School Programme — NYC Implementation: Interventions, Methods and Outcomes</i> , NYC Department of Transportation, New York City.                                                                                                    |
| 26.    | Journal — One author            | (Petzoldt, 2014)             | Petzoldt T (2014), <i>On the relationship between pedestrian gap acceptance and walking speed</i> , British Journal of Psychology, Vol 105 No. 4, November 2014, pp565–579. <a href="https://doi.org/10.1111/bjop.12055">https://doi.org/10.1111/bjop.12055</a> .                                                  |
| 27.    | E-Journal Article               | (ScienceDirect, 2020)        | ScienceDirect (2020), <i>Safety of children in school zones — A systematic review of school zone safety interventions</i> , [ejournal]. Safety Science, Vol 128, August 2020. Retrieved from <a href="https://www.sciencedirect.com">https://www.sciencedirect.com</a> (Accessed on 20 March 2025).                |
| 28.    | Report                          | (United Way, 2021)           | United Way of Bengaluru (2021), <i>YCARS — Young Change Agents for Road Safety: Programme Implementation Report</i> , United Way of Bengaluru, in partnership with 3M India and Concern for Road and Pedestrian Safety (CoRPS), Bengaluru.                                                                         |
| 29.    | Govt. / Int'l Org. Report       | (WHO, 2018)                  | World Health Organization (WHO) (2018), <i>Global Status Report on Road Safety 2018</i> , World Health Organization, Geneva.                                                                                                                                                                                       |

## SCHOOL ZONE SAFETY

| S. No. | Source Type               | In-text Citation   | Full Reference                                                                                                                                                                                                                                                                                                           |
|--------|---------------------------|--------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 30.    | Govt. / Int'l Org. Report | (WHO, 2021)        | World Health Organization (WHO) (2021), <i>Global Plan for the Decade of Action for Road Safety 2021–2030</i> , World Health Organization, Geneva. Retrieved from <a href="https://www.who.int/publications/i/item/9789240031029">https://www.who.int/publications/i/item/9789240031029</a> (Accessed on 20 March 2025). |
| 31.    | Govt. / Int'l Org. Report | (WHO, 2023)        | World Health Organization (WHO) (2023), <i>Global Status Report on Road Safety 2023</i> , World Health Organization, Geneva.                                                                                                                                                                                             |
| 32.    | Report                    | (WRI India, 2021a) | World Resources Institute (WRI) India (2021a), <i>Building Safe School Zones: A Collective Responsibility</i> , WRI India, Bengaluru.                                                                                                                                                                                    |
| 33.    | Report                    | (WRI India, 2021b) | World Resources Institute (WRI) India (2021b), <i>Safe Access to School: Urban Design and Policy Approaches</i> , WRI India, New Delhi.                                                                                                                                                                                  |

## APPENDIX A

## Technical Specification Tables

*These tables contain the complete IRC-parameter design specifications that support the proposals in Chapter 4. They are placed in the appendix to maintain readability of the main chapter text while providing the technical detail required for engineering estimation and drawing preparation.*

**Table A1: Raised Pedestrian Crossing — Complete Design Specification**

*Referenced at Section 4.3.2, Table 4.4. Per IRC:SP:32-2023, IRC:99-2018, and IRC:35-2015.*

| Design Parameter                              | Specification / Value                                                                 | IRC / Standard Reference                    |
|-----------------------------------------------|---------------------------------------------------------------------------------------|---------------------------------------------|
| <b>Platform height</b>                        | 75 mm standard; 100 mm on high-speed approaches (> 40 kmph prevailing speed)          | <i>IRC:99-2018 Cl. 5.4; IRC:SP:32-2023</i>  |
| <b>Approach ramp gradient</b>                 | 1:10 maximum (100 mm rise per 1,000 mm run)                                           | <i>IRC:99-2018 Cl. 5.4</i>                  |
| <b>Ramp length (for 75 mm platform)</b>       | 750 mm minimum; 1,000 mm recommended                                                  | <i>IRC:99-2018 Table 1</i>                  |
| <b>Platform length (in traffic direction)</b> | 2,500–3,500 mm (vehicle wheelbase accommodation)                                      | <i>IRC:99-2018 Table 1</i>                  |
| <b>Crossing width (pedestrian direction)</b>  | 4,000 mm minimum; 6,000 mm at school gate crossings                                   | <i>IRC:SP:32-2023 Cl. 7.2; IRC:103-2012</i> |
| <b>Carriageway coverage</b>                   | Full kerb-to-kerb width including cycle track                                         | <i>IRC:SP:32-2023</i>                       |
| <b>Platform surface — carriageway</b>         | Zebra stripes, white thermoplastic, 500 mm stripes / 500 mm gaps; glass-bead embedded | <i>IRC:35-2015 Cl. 8.3</i>                  |

## SCHOOL ZONE SAFETY

| Design Parameter                      | Specification / Value                                                                                                     | IRC / Standard Reference                          |
|---------------------------------------|---------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------|
| <b>Ramp surface</b>                   | Brushed concrete or anti-skid thermoplastic; retro-reflective yellow edge markers at ramp–platform junction               | <i>IRC:99-2018; IS 15477</i>                      |
| <b>Tactile paving</b>                 | Yellow blister pattern, 600 mm wide, at top and bottom of each ramp (both footpath and carriageway sides)                 | <i>IS 15477; IRC:103-2012 Cl. 6.4</i>             |
| <b>Kerb ramp at footpath junction</b> | Flush with platform (level crossing); 1.2 m minimum width; 1:12 gradient for footpath-side transitions only               | <i>IRC:103-2012 Cl. 6.3</i>                       |
| <b>Drainage</b>                       | 150 × 150 mm V-channel along full width at ramp-to-carriageway junction (downhill side); connected to kerb drainage inlet | <i>IRC:SP:32-2023; IRC:SP:20</i>                  |
| <b>Concrete specification</b>         | M30 PCC, 250 mm depth on compacted WMM base (150 mm) and subgrade                                                         | <i>MoRTH Road and Bridge Works Specifications</i> |
| <b>Stop line</b>                      | White thermoplastic, 300 mm wide, 1,500 mm before approach ramp toe                                                       | <i>IRC:35-2015 Cl. 9.1</i>                        |
| <b>Night visibility</b>               | Retro-reflective chevron delineators (pairs, 300 × 750 mm, yellow Type-III) on ramp kerbs; 600 mm spacing                 | <i>IRC:67-2012; MoRTH Safety Manual</i>           |
| <b>Maintenance cycle</b>              | Thermoplastic repainting: every 2 years or when reflectivity < IRC:35 threshold; civil inspection: annual                 | <i>IRC:35-2015 Cl. 12</i>                         |

**Table A2: Speed Hump (IRC Type-B) — Complete Specification**

*Referenced at Section 4.3.3. Per IRC:99-2018.*

## SCHOOL ZONE SAFETY

| Design Parameter        | Specification / Value                                                                                                    | IRC / Standard Reference                        |
|-------------------------|--------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------|
| <b>Hump type</b>        | Type-B sinusoidal (smooth sinusoidal profile; recommended for school zones)                                              | <i>IRC:99-2018 Cl. 5.2</i>                      |
| <b>Height</b>           | 75 mm above adjacent carriageway                                                                                         | <i>IRC:99-2018 Table 1</i>                      |
| <b>Base length</b>      | 3,700 mm (measured at carriageway level)                                                                                 | <i>IRC:99-2018 Table 1</i>                      |
| <b>Profile</b>          | Sinusoidal (ITE formula): $h = (H/2)(1 - \cos(\pi x/L))$ where $H = 75$ mm, $L = 1,850$ mm                               | <i>IRC:99-2018 Cl. 5.2; ITE Traffic Calming</i> |
| <b>Width</b>            | Full carriageway width (kerb to kerb); no gap between hump ends and kerb                                                 | <i>IRC:99-2018 Cl. 5.2</i>                      |
| <b>Surface</b>          | Hot-mix asphalt over concrete base, or pre-cast rubber hump bolted to carriageway; anti-skid surface mandatory           | <i>IRC:99-2018</i>                              |
| <b>Marking</b>          | W-15 cautionary sign 30 m before hump on each approach; yellow/black banding on hump face; 'SPEED HUMP' carriageway text | <i>IRC:67-2012; IRC:35-2015</i>                 |
| <b>Spacing</b>          | 85–100 m within STZ; not less than 50 m between consecutive devices                                                      | <i>IRC:99-2018 Cl. 6.1</i>                      |
| <b>Night visibility</b> | Retro-reflective horizontal markings on hump face; approach sign Grade III retroreflective                               | <i>IRC:67-2012</i>                              |
| <b>Structural</b>       | Concrete base M25, 200 mm depth; compacted sub-base 150 mm WMM                                                           | <i>MoRTH Specifications</i>                     |

**Table A3: Kerb Extension (Bulb-Out) — Complete Specification**

Referenced at Section 4.3.4 and Section 4.3.6. Per IRC:103-2012.

| Design Parameter                     | Specification / Value                                                                                   | IRC / Standard Reference                           |
|--------------------------------------|---------------------------------------------------------------------------------------------------------|----------------------------------------------------|
| <b>Projection into carriageway</b>   | 1,500–2,000 mm into the parking/shoulder lane (not into the moving traffic lane)                        | <i>IRC:103-2012 Cl. 5.8; adapted from NACTO</i>    |
| <b>Length</b>                        | Minimum 9,000 mm ( $\geq$ adjacent parked vehicle length 6,000 mm + 1,500 mm clearance each end)        | <i>IRC:103-2012 Cl. 5.8</i>                        |
| <b>Top surface</b>                   | Continuous with footpath paving material; level with footpath; 100 mm raised kerb on carriageway edge   | <i>IRC:103-2012</i>                                |
| <b>Moving traffic lane clearance</b> | Retained at full IRC:86 minimum width (3,000 mm for two-lane roads in sensitive zones)                  | <i>IRC:86-2018 Cl. 5.3</i>                         |
| <b>Parking prohibition</b>           | No parking within 9 m upstream and 3 m downstream of kerb extension on both approaches                  | <i>IRC:SP:32-2023; IRC:35-2015</i>                 |
| <b>Planting</b>                      | One tree or 600 mm max height low planting in kerb extension surface; root barrier to protect pavement  | <i>IRC:103-2012; BMC Urban Greening Guidelines</i> |
| <b>Night visibility</b>              | Retro-reflective delineator post (1,000 mm, orange, Type-IV) at carriageway edge of each kerb extension | <i>IRC:67-2012</i>                                 |

**Table A4: Raised Junction — Subhash Chowraha — Complete Specification**

Referenced at Section 4.3.5, Table 4.7. Per IRC:99-2018 and IRC:SP:32-2023.

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| Design Parameter                     | Specification / Value                                                                                        | IRC / Standard Reference                             |
|--------------------------------------|--------------------------------------------------------------------------------------------------------------|------------------------------------------------------|
| <b>Junction platform elevation</b>   | 100 mm above surrounding carriageway level; matching footpath level on all four junction arms                | <i>IRC:99-2018;</i><br><i>IRC:SP:32-2023 Cl. 7.3</i> |
| <b>Ramp gradient (all four arms)</b> | 1:10 maximum on all four arms; ramp length 1,000 mm for 100 mm platform                                      | <i>IRC:99-2018 Cl. 5.4</i>                           |
| <b>Platform surface area</b>         | Entire junction pavement from kerb to kerb on all arms; approximately 400 m <sup>2</sup> (field measurement) | <i>IRC:99-2018</i>                                   |
| <b>Platform surface finish</b>       | Exposed aggregate concrete or block paving, red/buff colour; anti-skid texture mandatory                     | <i>IRC:SP:32-2023</i>                                |
| <b>Pedestrian crossings</b>          | IRC:35-2015 zebra markings in white thermoplastic on all four arms of platform                               | <i>IRC:35-2015;</i><br><i>IRC:SP:32-2023</i>         |
| <b>Vehicle channelisation</b>        | Lane markings retained on each approach arm; give-way dashed line across each ramp; junction centre unmarked | <i>IRC:35-2015</i>                                   |
| <b>Drainage</b>                      | Perimeter V-channel (150 × 150 mm) around full junction platform perimeter; four inlet points at ramp bases  | <i>IRC:SP:20</i>                                     |
| <b>Structural design</b>             | M30 PCC, 300 mm depth on compacted WMM; design wheel load 10 tonnes (medium commercial vehicle)              | <i>MoRTH Road and Bridge Works Specifications</i>    |
| <b>Corner bollards</b>               | Retro-reflective flexible bollards, 900 mm height, at all four junction corner quadrants                     | <i>IRC:67-2012</i>                                   |

**Table A5: Footpath — Complete Design Specification**

Referenced at Section 4.4.1, Table 4.9. Per IRC:103-2012.

| Design Parameter                                        | Specification / Value                                                                                         | IRC / Standard Reference                            |
|---------------------------------------------------------|---------------------------------------------------------------------------------------------------------------|-----------------------------------------------------|
| <b>Clear footpath width — school frontage (5 gates)</b> | 2,400 mm minimum unobstructed clear width                                                                     | <i>IRC:103-2012 Cl. 5.2; IRC:SP:32-2023 Cl. 7.4</i> |
| <b>Clear footpath width — SPZ general</b>               | 1,800 mm minimum                                                                                              | <i>IRC:103-2012 Cl. 5.2</i>                         |
| <b>Clear footpath width — STZ</b>                       | 1,500 mm minimum                                                                                              | <i>IRC:103-2012 Cl. 5.2</i>                         |
| <b>Surface material</b>                                 | Interlocking concrete paving blocks (ICPB), 60 mm thick, M30 equivalent; on 25 mm sand bed on 100 mm DLC base | <i>IRC:SP:63-2004; IS 15658</i>                     |
| <b>Surface friction coefficient</b>                     | Minimum 0.45 (wet condition) per IS 9284                                                                      | <i>IRC:103-2012; IS 9284</i>                        |
| <b>Longitudinal gradient</b>                            | Maximum 1:20 (5%); preferred 1:40 (2.5%)                                                                      | <i>IRC:103-2012 Cl. 5.5</i>                         |
| <b>Cross-fall</b>                                       | 1:40 (2.5%) toward carriageway for drainage                                                                   | <i>IRC:103-2012 Cl. 5.5</i>                         |
| <b>Kerb height</b>                                      | 150 mm upstand kerb between footpath and carriageway; granite or concrete, M30                                | <i>IRC:103-2012 Cl. 5.3</i>                         |
| <b>Buffer strip</b>                                     | 500 mm minimum between footpath clear width and carriageway edge; for trees, utilities, bollards              | <i>IRC:SP:32-2023; IRC:103-2012</i>                 |
| <b>Junction with driveways</b>                          | Footpath raised over driveway (vehicle ascends to footpath level); driveway gradient 1:6 maximum              | <i>IRC:103-2012 Cl. 5.7</i>                         |

## SCHOOL ZONE SAFETY

| Design Parameter                  | Specification / Value                                                               | IRC / Standard Reference                     |
|-----------------------------------|-------------------------------------------------------------------------------------|----------------------------------------------|
| <b>Obstruction clearance</b>      | No object within 1.5 m clear width above 50 mm height; utility covers flush-mounted | <i>IRC:103-2012 Cl. 5.6</i>                  |
| <b>Maintenance responsibility</b> | BMC Zone Office (Zone 4); monthly inspection during monsoon; quarterly otherwise    | <i>BMC Act 1956; Ward Maintenance Manual</i> |

**Table A6: Kerb Ramp — Complete Specification**

*Referenced at Section 4.4.2, Table 4.10. Per IRC:103-2012 Cl. 6.3 and IS 15477.*

| Design Parameter                              | Specification / Value                                                                       | IRC / Standard Reference                      |
|-----------------------------------------------|---------------------------------------------------------------------------------------------|-----------------------------------------------|
| <b>Type</b>                                   | Perpendicular ramp (direct descent along crossing alignment)                                | <i>IRC:103-2012 Cl. 6.3; IS 15477</i>         |
| <b>Gradient</b>                               | 1:12 maximum; preferred 1:16 for children and wheeled mobility devices                      | <i>IRC:103-2012 Cl. 6.3</i>                   |
| <b>Width</b>                                  | 1,200 mm minimum; equal to crossing width where crossing < 1,500 mm                         | <i>IRC:103-2012 Cl. 6.3</i>                   |
| <b>Level landing</b>                          | 1,500 × 1,500 mm level landing at footpath level before ramp commences                      | <i>IRC:103-2012 Cl. 6.3</i>                   |
| <b>Surface</b>                                | Brushed finish concrete or anti-skid textured paving blocks; friction coefficient ≥ 0.5 wet | <i>IRC:103-2012; IS 9284</i>                  |
| <b>Tactile warning paving — footpath side</b> | Blister-pattern, yellow tactile tiles, 600 mm wide × ramp width, at top of ramp             | <i>IS 15477 Table 1; IRC:103-2012 Cl. 6.4</i> |

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| Design Parameter                                 | Specification / Value                                                                         | IRC / Standard Reference    |
|--------------------------------------------------|-----------------------------------------------------------------------------------------------|-----------------------------|
| <b>Tactile warning paving — carriageway side</b> | Blister-pattern, yellow tactile tiles, 600 mm wide, at bottom of ramp, flush with carriageway | <i>IS 15477</i>             |
| <b>Detectable colour contrast edge</b>           | Yellow on grey; minimum 40 mm colour band at ramp perimeter edges                             | <i>IS 15477</i>             |
| <b>Grade break at base</b>                       | Maximum 13 mm vertical offset between ramp bottom and adjacent road surface; must be flush    | <i>IRC:103-2012 Cl. 6.3</i> |
| <b>Drainage</b>                                  | Cross-fall 2% toward road surface; no ponding at ramp base                                    | <i>IRC:103-2012</i>         |

**Table A7: Pick-up/Drop-off Bay — Complete Specification**

*Referenced at Section 4.4.7, Table 4.16. Per IRC:SP:32-2023 Cl. 8.2.*

| Design Parameter                   | Specification / Value                                                                                  | IRC / Standard Reference                      |
|------------------------------------|--------------------------------------------------------------------------------------------------------|-----------------------------------------------|
| <b>Bay length</b>                  | Minimum 30 m (5 vehicles at 6 m/vehicle + 1.5 m clearance each end)                                    | <i>IRC:SP:32-2023 Cl. 8.2</i>                 |
| <b>Bay width</b>                   | 2,500 mm parallel to carriageway; single-file pull-in; separated from live lane by 150 mm upstand kerb | <i>IRC:SP:32-2023 Cl. 8.2</i>                 |
| <b>Approach taper</b>              | 1:10 minimum entry taper; 1:6 exit taper                                                               | <i>IRC:SP:32-2023</i>                         |
| <b>Pedestrian path through bay</b> | 1,200 mm wide path from bay to school gate; protected by 300 mm low kerb or flexible delineators       | <i>IRC:SP:32-2023;</i><br><i>IRC:103-2012</i> |

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| Design Parameter           | Specification / Value                                                                                                                                                              | IRC / Standard Reference                                 |
|----------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------|
| Bay surface markings       | Yellow box hatching; numbered stalls (1–5); directional arrows; 'LOADING ZONE' text                                                                                                | <i>IRC:35-2015</i>                                       |
| Queuing prevention sign    | 'Bay Full — Please Proceed and Return' advance information board at 50 m before bay on approach                                                                                    | <i>IRC:SP:32-2023</i>                                    |
| Auto-rickshaw staging area | 15-vehicle capacity on Link Road No. 2 eastern shoulder, $\geq 100$ m from nearest school gate; shade structure; drinking water tap; Level-1 EV charging points (5 no.) in Phase 3 | <i>IRC:SP:32-2023; RTO guidelines; MP EV Policy 2019</i> |

*End of Appendix A.*

## Appendix B

### SURVEY QUESTIONNAIRE

#### Section 1: Questionnaire for Teachers

##### 1. What is your Gender?

- ☐ Male
- ☐ Female
- ☐ Other

##### 2. Which age group do you belong?

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- ☐ **22-30**
- ☐ **30-40**
- ☐ **40-50**
- ☐ **50-60**
- ☐ **> 60**

### **3. What is range of your monthly income?**

- ☐ **20,000-40,000**
- ☐ **40,000-60,000**
- ☐ **60,000-80,000**
- ☐ **80,000-1 lakhs**
- ☐ **> 1 lakh**

### **4. How do you commute to school? (Can select multiple options)**

- ☐ **Walk**
- ☐ **Bicycle**
- ☐ **Bus**
- ☐ **Auto/Magic**
- ☐ **Bike**
- ☐ **Car**

### **5. How easy or difficult it is to walk near your school area?**

- ☐ **Very Easy**
- ☐ **Easy**
- ☐ **Neutral**
- ☐ **Difficult**
- ☐ **Very Difficult**

### **6. If walking near your school is difficult, what are the reasons?**

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|                                                          | Strongly Agree           | Agree                    | Neutral                  | Disagree                 | Strongly Disagree        |
|----------------------------------------------------------|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|
| Vehicles move fast to make walking/crossing unsafe       | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| Illegal or unsafe parking                                | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| Encroached crosswalks and sidewalks                      | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| Lack of pedestrian footpath                              | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| Unavailability of pedestrian signals and crossing guards | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| Road signages are not enough                             | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| Poor visibility due to parked vehicles                   | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| Unsafe behaviour by users                                | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| Other:<br>_____                                          | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |

**7. Do you agree that area near your school needs improvements for safety of children?**

- ☐ Strongly Agree
- ☐ Agree
- ☐ Neutral
- ☐ Disagree
- ☐ Strongly Disagree

**8. Did your school conduct any road safety programs?**

- ☐ Yes

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- ☐ **No**

**9. Have you ever witnessed or experienced any minor or major accident in area around your school? If yes, share details in brief in last (other) option.**

- ☐ **Yes**
- ☐ **No**

**Other:**

---

---

**Section 2: Questionnaire for Students (Class 1st to 7th)1. Which class are you studying in?**

- ☐ **1st**
- ☐ **2nd**
- ☐ **3rd**
- ☐ **4th**
- ☐ **5th**
- ☐ **6th**
- ☐ **7th**

**2. What is your age?**

**Age:** \_\_\_\_\_

**3. What is your Gender?**

- ☐ **Male**
- ☐ **Female**
- ☐ **Other**

**4. How do you commute to school?**

- ☐ **Walk**
- ☐ **Bicycle**

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- ☐ **Bus**
- ☐ **Auto/Magic**
- ☐ **Bike**
- ☐ **Car**

**5. With whom do you travel while coming to school?**

- ☐ **Alone**
- ☐ **With friends**
- ☐ **With family**
- ☐ **With school staff**

**6. How do you commute from school?**

- ☐ **Walk**
- ☐ **Bicycle**
- ☐ **Bus**
- ☐ **Auto/Magic**
- ☐ **Bike**
- ☐ **Car**

**7. With whom do you travel while coming from school?**

- ☐ **Alone**
- ☐ **With friends**
- ☐ **With family**
- ☐ **With school staff**

**8. Select the option according to how much you agree with the following reasons for choosing your mode of travel to school.**

|  | <b>Strongly Agree</b> | <b>Agree</b> | <b>Neutral</b> | <b>Disagree</b> | <b>Strongly Disagree</b> |
|--|-----------------------|--------------|----------------|-----------------|--------------------------|
|--|-----------------------|--------------|----------------|-----------------|--------------------------|

## SCHOOL ZONE SAFETY

|                                              |                          |                          |                          |                          |                          |
|----------------------------------------------|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|
| <b>It is good for health</b>                 | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| <b>It is the safest option</b>               | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| <b>It is easy to use</b>                     | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| <b>The distance is too far to walk/cycle</b> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| <b>It is good for the environment</b>        | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| <b>I have no other way to reach school</b>   | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| <b>It is the cheapest mode</b>               | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| <b>It is the fastest mode</b>                | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| <b>None of the above apply</b>               | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |

**9. How often do you walk on the footpath/sidewalk near the school?**

- ☐ **Always**
- ☐ **Often**
- ☐ **Sometimes**
- ☐ **Rarely**
- ☐ **Never**

**10. How often do you do the following when crossing the road?**

|                                              | <b>Always</b>            | <b>Often</b>             | <b>Sometimes</b>         | <b>Rarely</b>            | <b>Never</b>             |
|----------------------------------------------|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|
| <b>Use the zebra crossing</b>                | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| <b>Follow a teacher/guard while crossing</b> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |

## SCHOOL ZONE SAFETY

|                                                  |                          |                          |                          |                          |                          |
|--------------------------------------------------|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|
| <b>Look both sides before crossing</b>           | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| <b>Run quickly across the road</b>               | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| <b>Wait for someone to help you</b>              | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| <b>Cross anywhere (not at crossing)</b>          | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| <b>Wait for vehicles to stop before crossing</b> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |

### 11. How fast do vehicles usually travel near your school?

- ☐ Very fast
- ☐ Fast
- ☐ Normal
- ☐ Slow

### 12. How safe do you feel near your school in the following situations?

|                                                          | Very safe                | Safe                     | Neutral                  | Unsafe                   | Very Unsafe              |
|----------------------------------------------------------|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|
| <b>While walking on the footpath/sidewalk</b>            | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| <b>While walking on the road (no footpath available)</b> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| <b>While crossing the road near school</b>               | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| <b>Near parked vehicles or traffic congestion</b>        | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |

## SCHOOL ZONE SAFETY

|                               |                          |                          |                          |                          |                          |
|-------------------------------|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|
| Near the school entrance gate | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
|-------------------------------|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|

### 13. What makes you scared or uncomfortable?

- ☐ Fast vehicles
- ☐ No place to walk
- ☐ Too much traffic
- ☐ Big vehicles
- ☐ Another road user

### 14. How important are the following measures of road safety near your school?

|                               | Very important           | Important                | Neutral                  | Slightly important       | Not important            |
|-------------------------------|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|
| Lower speed limit for vehicle | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| Footpath/Pedestrian pathway   | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| Zebra crossing                | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| Speed breakers                | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| Crossing guards               | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| Parking/Drop-off area         | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |

## SCHOOL ZONE SAFETY

|                                                             |                          |                          |                          |                          |                          |
|-------------------------------------------------------------|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|
| <b>Pedestrian signals</b>                                   | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| <b>CCTV (Video surveillance)</b>                            | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| <b>Road markings (lanes, arrows, school zone)</b>           | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| <b>Cycle lane (if needed)</b>                               | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| <b>Road surface condition (no potholes, smooth walking)</b> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| <b>Road safety awareness among students &amp; drivers</b>   | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |

**15. Are you aware of any road safety rules?**

- ☐ **Extremely aware**
- ☐ **Very aware**
- ☐ **Moderately aware**
- ☐ **Slightly aware**
- ☐ **Not at all aware**

**16. Where do your parents/auto/bus drop you off?**

- ☐ **In front of school**
- ☐ **On roadway**
- ☐ **Opposite side of roadway**
- ☐ **In a parking lot**
- ☐ **Other**

**17. Have you ever witnessed or experienced any minor or major accident in area around your school? If yes, share details in brief in last (other) option.**

## SCHOOL ZONE SAFETY

☐ **Yes**

☐ **No**

**Other:**

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### **Section 3: Questionnaire for Students (Class 8th to 12th)**

**1. Which class are you studying in?**

☐ **8th**

☐ **9th**

☐ **10th**

☐ **11th**

☐ **12th**

☐ **Graduation**

☐ **Diploma**

**2. What is your age?**

**Age:** \_\_\_\_\_

**3. What is your Gender?**

☐ **Male**

☐ **Female**

☐ **Other**

**4. How do you commute to school?**

☐ **Walk**

☐ **Bicycle**

☐ **Bus**

## SCHOOL ZONE SAFETY

- ☐ **Auto/Magic**
- ☐ **Bike**
- ☐ **Car**

### 5. With whom do you travel while coming to school?

- ☐ **Alone**
- ☐ **With friends**
- ☐ **With family**
- ☐ **With school staff**

### 6. How do you commute from school?

- ☐ **Walk**
- ☐ **Bicycle**
- ☐ **Bus**
- ☐ **Auto/Magic**
- ☐ **Bike**
- ☐ **Car**

### 7. With whom do you travel while coming from school?

- ☐ **Alone**
- ☐ **With friends**
- ☐ **With family**
- ☐ **With school staff**

### 8. Select the option according to how much you agree with the following reasons for choosing your mode of travel to school.

|                              | <b>Strongly Agree</b>    | <b>Agree</b>             | <b>Neutral</b>           | <b>Disagree</b>          | <b>Strongly Disagree</b> |
|------------------------------|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|
| <b>It is good for health</b> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |

## SCHOOL ZONE SAFETY

|                                              |                          |                          |                          |                          |                          |
|----------------------------------------------|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|
| <b>It is the safest option</b>               | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| <b>It is easy to use</b>                     | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| <b>The distance is too far to walk/cycle</b> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| <b>It is good for the environment</b>        | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| <b>I have no other way to reach school</b>   | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| <b>It is the cheapest mode</b>               | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| <b>It is the fastest mode</b>                | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| <b>None of the above apply</b>               | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |

**9. What is the approximate distance from your home to your school?**

- ☐ <500m
- ☐ 500m-1km
- ☐ 1-3km
- ☐ 3-5km
- ☐ > 5km

**10. How fast do vehicles usually travel near your school?**

- ☐ Very fast
- ☐ Fast
- ☐ Normal
- ☐ Slow

**11. How safe do you feel near your school in the following situations?**

## SCHOOL ZONE SAFETY

|                                                   | Very safe                | Safe                     | Neutral                  | Unsafe                   | Very Unsafe              |
|---------------------------------------------------|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|
| While walking on the footpath/sidewalk            | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| While walking on the road (no footpath available) | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| While crossing the road near school               | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| Near parked vehicles or traffic congestion        | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| Near the school entrance gate                     | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |

### 12. What makes you scared or uncomfortable?

- ☐ Fast vehicles
- ☐ No place to walk
- ☐ Too much traffic
- ☐ Big vehicles
- ☐ Another road user

### 13. How important are the following measures of road safety near your school?

|                             | Very important           | Important                | Neutral                  | Slightly important       | Not important            |
|-----------------------------|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|
| Footpath/Pedestrian pathway | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| Zebra crossing              | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| Speed breakers              | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| Traffic police presence     | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |

## SCHOOL ZONE SAFETY

|                                                             |                          |                          |                          |                          |                          |
|-------------------------------------------------------------|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|
| <b>Parking/Drop-off area</b>                                | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| <b>Traffic signals</b>                                      | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| <b>Road markings (lanes, arrows, school zone)</b>           | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| <b>CCTV (Video surveillance)</b>                            | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| <b>Median</b>                                               | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| <b>Cycle lane (if needed)</b>                               | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| <b>Road surface condition (no potholes, smooth walking)</b> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| <b>Road safety awareness among students &amp; drivers</b>   | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |

### 14. How risky are the following factors on your way to school?

|                                        | <b>Not Risky</b>         | <b>Slight Risk</b>       | <b>Moderate Risk</b>     | <b>High Risk</b>         | <b>Very High Risk</b>    |
|----------------------------------------|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|
| <b>Fast-moving vehicles</b>            | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| <b>No safe place to cross the road</b> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| <b>No pedestrian walkway/footpath</b>  | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| <b>Parking or drop-off chaos</b>       | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| <b>Stray animals</b>                   | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |

### 15. Do you agree that the school area needs more safety improvements?

## SCHOOL ZONE SAFETY

- ☐ **Strongly agree**
- ☐ **Agree**
- ☐ **Neither agree nor disagree**
- ☐ **Disagree**
- ☐ **Strongly disagree**

**16. Where do your parents/auto/bus drop you off?**

- ☐ **In front of school**
- ☐ **On roadway**
- ☐ **Opposite side of roadway**
- ☐ **In a parking lot**
- ☐ **Other**

**17. How Easy the situations are during pick-up and drop-off**

- ☐ **Very easy**
- ☐ **Easy**
- ☐ **Neutral**
- ☐ **Difficult**
- ☐ **Very difficult**

**18. Do you agree that safety training or awareness programs are needed?**

- ☐ **Strongly agree**
- ☐ **Agree**
- ☐ **Neither agree nor disagree**
- ☐ **Disagree**
- ☐ **Strongly disagree**

**19. Have you ever witnessed or experienced any minor or major accident in area around your school? If yes, share details in brief in last (other) option.**

## SCHOOL ZONE SAFETY

☐ Yes

☐ No

**Other:**

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**20. If you could change one thing to make routes safer, what would it be?**

**Answer:**

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## ANNEXURE I

While purchasing/hiring buses, school is advised to check for the following:

### **Part A: Driving Ability Check**

| <b>Initial Checks while recruiting a Driver for School Bus</b> |                                                                                                                                                               |
|----------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1.                                                             | Commercial Driving License                                                                                                                                    |
| 2.                                                             | High School Diploma                                                                                                                                           |
| 3.                                                             | Possession of a safe driving record                                                                                                                           |
| 4.                                                             | Knowledge of the provisions of the Motor Vehicle Act and the Safety measures as applied to the operation of vehicles used in the transport of school children |
| 5.                                                             | Knowledge of basic first aid practices, procedures, and techniques                                                                                            |
| 6.                                                             | Ability to read and write at a level necessary to successfully perform the required duties                                                                    |
| 7.                                                             | Ability to understand and carry out both oral and written instructions in an independent manner                                                               |
| 8.                                                             | Ability to establish and maintain proper student conduct on school vehicle                                                                                    |
| 9.                                                             | Ability to meet the physical requirements necessary to safely and effectively perform required duties (Physical Fitness Report)                               |
| 10.                                                            | Mental Fitness report                                                                                                                                         |

### **Part B: Checklist for School Bus Drivers**

## SCHOOL ZONE SAFETY

| Bus Number         | Driver's Name          | Date             | Meter Reading        |
|--------------------|------------------------|------------------|----------------------|
|                    |                        |                  |                      |
| Trip Starting Time | Trip Starting Location | Trip Ending Time | Trip Ending Location |
|                    |                        |                  |                      |

### Part C: Before Starting the Engine (pre-trip inspections)

| Vehicle Components                               | OK | Not OK | Remarks, If Not OK |
|--------------------------------------------------|----|--------|--------------------|
| Tire Pressure                                    |    |        |                    |
| Brake                                            |    |        |                    |
| Fluid level                                      |    |        |                    |
| Lights                                           |    |        |                    |
| Retro reflective tapes on School Bus             |    |        |                    |
| Windows and Doors                                |    |        |                    |
| Windshield                                       |    |        |                    |
| Wiper                                            |    |        |                    |
| Mirrors                                          |    |        |                    |
| Check under the bus if there are traces of leaks |    |        |                    |
| Engine Check                                     |    |        |                    |
| Light and horn                                   |    |        |                    |
| Gears and pedals                                 |    |        |                    |
| Emergency and Safety Equipment's                 |    |        |                    |
| Meters and Gauges                                |    |        |                    |
| Wheel                                            |    |        |                    |

## SCHOOL ZONE SAFETY

### Part D: Regular Check-Ups

| Test                                                                                                               | Interval                  | Where to get it done?                        |
|--------------------------------------------------------------------------------------------------------------------|---------------------------|----------------------------------------------|
| Pollution Under Control                                                                                            | Annually                  | Pollution Checking Centers                   |
| Driving and student management skills                                                                              | Annually                  | School Management Committee & Traffic Police |
| Communicates all route changes and hazards                                                                         | Daily                     | School Management                            |
| Update routes and maps and adjust timetables                                                                       | Daily                     | As Above                                     |
| Performs post-trip inspection to check lost articles or sleeping students                                          | Daily                     | School Management                            |
| Monitors student behaviour and provides written reports for all incidents of misconduct to the building principals | Daily                     | As Above                                     |
| In-service meeting and practice drill and training for CPR/First Aid and road safety                               | Monthly and as per MV Act | As Above                                     |

### Part E: Regular Check-Ups

| Supervision and Assistance while alighting and boarding of Students |    |        |                    |
|---------------------------------------------------------------------|----|--------|--------------------|
| Check the exterior parts                                            | OK | Not OK | Remarks, if not OK |
| Assistant                                                           |    |        |                    |
| Proper boarding/alighting zone?                                     |    |        |                    |
| Evacuation arrangement, in case of emergency                        |    |        |                    |

**ROAD SIGNS IN SCHOOL ZONE**

| Sign and Description                                                                                                                                                                                                                                     | Figure                                                                                                                       |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------|
| Mandatory / Regulatory and Compulsory                                                                                                                                                                                                                    | Direction Control Signs                                                                                                      |
| To be located at stretch, where vehicle need to stop before entering a main carriageway.                                                                                                                                                                 | <br>Stop Sign                             |
| To reduce vehicle speeds to improve pedestrian safety during times of high pedestrian activity (i.e., arrival and dismissal). Oversized sign may be used for applications that require increased emphasis, improved recognition or increased legibility. | <br>Speed Limit Sign                     |
| For sections of bad accident history or substandard curves, speed limit sign can be provided in yellow backing board to make it more prominent.                                                                                                          | <br>Speed Limit Sign with Backing Plate |
| The sign should be provided on the roads where No Parking of vehicles is allowed. This sign may be used along with time restriction indicating morning and evening peak periods.                                                                         | <br>Parking Prohibited                  |

## SCHOOL ZONE SAFETY

|                                                                                                                                                                                                                   |                                                                                                                                         |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------|
| <p>The sign should be erected where parking is not allowed on the footpath.</p>                                                                                                                                   | <br><b>Parking Prohibited on the Footpath</b>        |
| <p>This sign shall indicate the point at which all prohibitions notified at the beginning of school zone for moving vehicles ceases to apply.</p>                                                                 | <br><b>Restriction Ends</b>                          |
| <p>This sign shall mean that only pedestrians are allowed, and the traffic is not allowed on this road / carriageway. The sign may be supported by supplementary plate with "PEDESTRIANS ONLY" written on it.</p> | <br><b>Pedestrian Only</b>                          |
| <p>The sign shall notify cyclists that they must use the cycle track at the entrance to which it is placed and shall notify the drivers of other vehicles that they are not entitled to use the track.</p>        | <br><b>Compulsory Cycle Track / Cycle Only</b>     |
| <p>This sign shall be used to segregate cycle and pedestrian lanes.</p>                                                                                                                                           | <br><b>Compulsory Cyclist and Pedestrian Route</b> |
| <b>Cautionary Signs / Warning Signs</b>                                                                                                                                                                           |                                                                                                                                         |

## SCHOOL ZONE SAFETY

|                                                                                                                                                                                                                                                                        |                                                                                                                                                         |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------|
| <p>Cautionary signs should be provided at the start of a school zone to warn motorists of the presence of a school and hence the possibility of children entering the roadway. The background of school zone ahead sign shall be fluorescent yellow- green colour.</p> |  <p><b>School Ahead with fluorescent Yellow Green Background</b></p> |
| <p>The sign should be erected in advance on approaches to at-grade pedestrian crossing.</p>                                                                                                                                                                            |  <p><b>Pedestrian Crossing</b></p>                                   |
| <p>For sections of bad crash history or substandard curves, where visibility of the crossing is impaired by a bend or hump in the road pedestrian crossing sign can be provided in yellow backing board to make it more prominent.</p>                                 |  <p><b>Pedestrian Crossing with Backing Board</b></p>               |
| <p>This sign is posted in situation where the Cycle Route is approaching, and drivers are required to slow down. The sign should be erected in advance of cycle crossing.</p>                                                                                          |  <p><b>Cycle Route Ahead</b></p>                                   |
| <b>Facility Information Signs</b>                                                                                                                                                                                                                                      |                                                                                                                                                         |
| <p>This sign provided information about cycle lane to road users.</p>                                                                                                                                                                                                  |  <p><b>Cycle Lane</b></p>                                          |

## SCHOOL ZONE SAFETY

|                                                                                                                                         |                                                                                                                                   |
|-----------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------|
| <p>This sign shall be used to inform the vehicles about Contra flow of cycles and shall be installed before beginning of such lane.</p> |  <p><b>Contra Flow Cycle Lane</b></p>          |
| <p>This sign shall be used at pedestrian crossing to inform the road users about the presence of pedestrian crossing.</p>               |  <p><b>Pedestrian Crossing Information</b></p> |
| <p>This sign shall be installed near the speed breakers / Humps to inform the road users about the exact location of the hump.</p>      |  <p><b>Speed hump</b></p>                     |
| <p>This sign should be erected at the places where the buses are designed to stop.</p>                                                  |  <p><b>Bus Stop</b></p>                      |
| <p>This sign is installed to inform the drivers of the presence of reserved bus lane in the carriageway.</p>                            |  <p><b>Bus Lane</b></p>                      |

## SCHOOL ZONE SAFETY

|                                                                                                                                                                                                         |                                                                                                                                                                                     |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <p>Dedicated and marked parking should be provided by the institution either within premises or at the entrance and shall not spill over to connected public roads.</p>                                 |  <p style="text-align: center;"><b>Parking</b></p>                                               |
| <p>The accessible parking area should be indicated using a signage reserved for vehicle parking for users with disabilities. The wheelchair in the sign should always be shown facing to the right.</p> |  <p style="text-align: center;"><b>Parking Information for<br/>Persons with Disabilities</b></p> |
| <p>The sign should be erected where the parking is not allowed to specific durations for traffic management.</p>                                                                                        |  <p style="text-align: center;"><b>Parking Restriction for<br/>Traffic Management</b></p>       |
| <p>The sign should be erected at Drop and Ride designated area for parents picking up or dropping their children by circulation of vehicles.</p>                                                        |  <p style="text-align: center;"><b>Drop and Ride Facilities</b></p>                            |

## SCHOOL ZONE SAFETY

Pickup and drop-off point near school entrances marked by wheelchair (access) symbol painted on the floor and on a pole of height 2 m shall be provided for passengers / children with impaired mobility as they often move slowly and therefore are more vulnerable.



**Accessible Boarding**

**ADDITIONAL SAFETY MEASURES FOR SCHOOL ZONES**

| <b>Road Markings and other Safety Measures</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |                                                                                                                                                      |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------|
| <p>Clear Road Marking to denote where parents are allowed to pick up and drop off the students.</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |  <p><b>Marking of Student Drop off area</b></p>                   |
| <p>Designated car parking spaces may be arranged perpendicular or parallel to the kerb. Dropped kerbs will facilitate access to the footpath for persons using wheelchairs.</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                |  <p><b>Accessible Parking with Aisle Space and Kerb Ramp</b></p> |
| <p>On depressed refuge islands as well as on footpaths, Concrete Bollards or Flexible Retro Reflective Bollards (having two numbers of white retro reflective sheeting of 100 mm width of Type IV grade pasted on them) must be fixed at each end, Such provision will help to forewarn the vehicles of the impending obstruction on the road during the night. Such bollards should be 0.5 - 0.7 m high with a clear width of 0.6 m between them and the other one with 0.9 m clear width for wheelchairs. These bollards can be installed at property entrances and ramps to prevent parking of vehicles, especially cars, on footpaths.</p> |  <p><b>Bollards</b></p>                                         |
| <p>Three sets of Transverse Bar Marking (TBM) with each set having 6 bars (conforming to IRC:35) measuring a thickness of 15 mm shall be provided on the main corridor as a softer treatment so as to curtail the speed.</p>                                                                                                                                                                                                                                                                                                                                                                                                                   |  <p><b>Typical provision of TBM on road</b></p>                 |

## SCHOOL ZONE SAFETY

Synthetic rubber-based sheet coloured/graphic/symbol marking with thickness less than 2 mm with embossed top PVC film with Skid Resistant properties up to 40 British Pendulum Number when tested in accordance to ASTM E 303. Suitable for application in indoor and outdoor (Pedestrian pathways and Cycle Track) on various surface such as asphalt, concrete, tiles, paver block, etc.

