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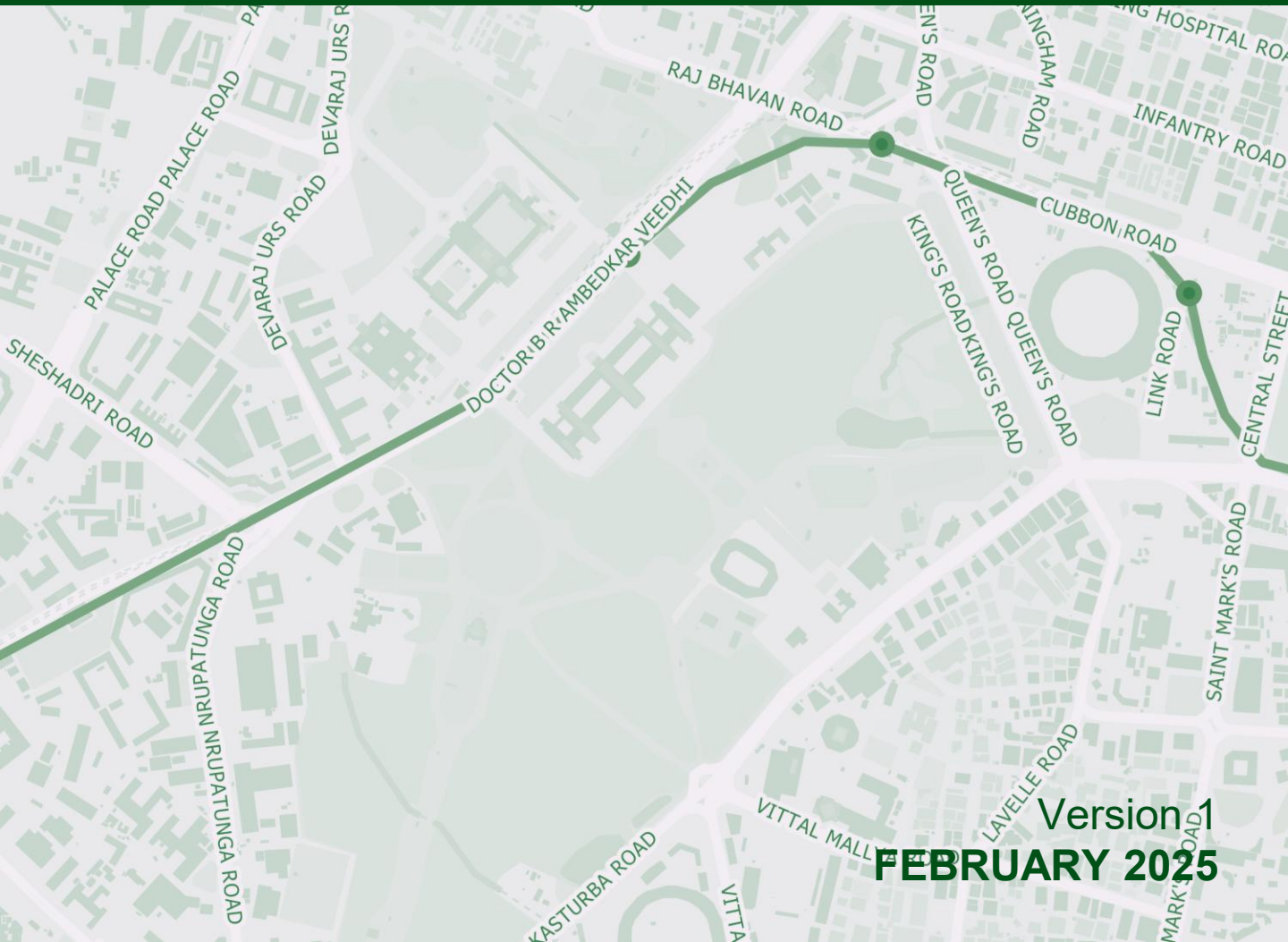
NAMMA RASTE KAIPIDI

Towards Safe, Inclusive and Resilient Roads in Bengaluru



Version 1

FEBRUARY 2025

Knowledge Partners

IISc Sustainable Transportation Lab (IST Lab)

भारतीय विज्ञान संस्थान

Celebrating 15 Years of Contribution to Sustainable Development

WRI INDIA

Shri D K Shivakumar

Deputy Chief Minister, Government of Karnataka

"The launch of the **Namma Raste Kaipidi** marks a significant step toward improving Bengaluru's road infrastructure. With a vast 12,000+ km road network, ensuring quality and longevity in road design and maintenance is crucial. This document provides a structured approach, integrating best practices and scientific advancements in road management. By streamlining processes, we can enhance safety, reduce congestion, and improve mobility for all residents, making our city more livable and resilient."

Shalini Rajneesh

IAS, Chief Secretary, Government of Karnataka

"Efficient governance relies on well-defined processes, and **the *Namma Raste Kaipidi*** is a crucial step toward institutionalizing best practices in road infrastructure. By standardizing design, construction, and maintenance protocols, this handbook will help streamline projects, enhance accountability, and improve road quality across Bengaluru's 12,000+ km network. A structured approach like this ensures that public resources are utilized effectively, delivering safer and more reliable roads for all citizens."

S R Umashankar

IAS, Additional Chief Secretary, UDD, Administrator of Bengaluru, Government of Karnataka

"A well-planned and efficiently managed road network is the backbone of urban development. As Bengaluru grows, the ***Namma Raste Kaipidi*** provides a critical framework to streamline road design, construction, and maintenance. By integrating scientific advancements and best practices, this initiative will enhance road quality, improve connectivity, and support sustainable urban mobility. With a structured approach, we can build roads that are not only durable but also contribute to a more resilient and livable city. Since Bengaluru has emerged as a global city, all the amenities and the infrastructure shall be of world standards, in its design and execution."

Tushar Giri Nath

IAS, Chief Commissioner, Bruhat Bengaluru Mahanagara Palike

"A resilient road network is built on efficient planning, timely maintenance, and the adoption of smart technologies. The **Namma Raste Kaipidi** will serve as a vital resource, ensuring uniformity in road construction and upkeep across BBMP's extensive network. By implementing standardized procedures and real-time monitoring, we can reduce frequent breakdowns, minimize costs, and ensure better roads for Bengaluru's citizens."

Avinash Menon

IAS, Special Commissioner (Projects),
Bruhat Bengaluru Mahanagara Palike

“Infrastructure projects in a dynamic city like Bengaluru require precision, innovation and accountability. The **Namma Raste Kaipidi** will serve as a vital guide for project execution, ensuring that roadworks are carried out efficiently and sustainably. By adopting a structured methodology and integrating modern technology, we can enhance the quality of Bengaluru’s roads, reduce disruptions, and improve overall urban mobility for residents and businesses alike.”

Dr B S Prahallad

Engineer-in-Chief,
Bruhat Bengaluru Mahanagara Palike

"Road durability depends on scientific design, quality materials, and precise execution. The **Namma Raste Kaipidi** offers a clear roadmap for engineers to follow, from design to long-term maintenance. By using advanced construction techniques and ensuring rigorous quality control, we can build roads that withstand wear and tear, minimize repair costs, and enhance overall urban mobility."

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A. BACKGROUND

Bengaluru, one of the fastest-growing cities globally, has a population exceeding 14 million and over 12 million registered vehicles. As a major economic hub, the city's roads also accommodate significant vehicular movements from other states and regions. Efficient road infrastructure is vital for Bengaluru's mobility and economic activity. The Bruhat Bengaluru Mahanagara Palike (BBMP) is responsible for the planning, development, and maintenance of approximately 12,800 km of roads, including arterial, sub-arterial, and collector roads. The BBMP Engineering Department works tirelessly to meet the demands of a rapidly growing city, striving to deliver quality roads despite various institutional and procedural challenges, including some beyond its direct control.

While BBMP oversees road infrastructure, multiple agencies—including BWSSB, BESCOM, KPTCL, BMRCL, and GAIL—manage utilities such as water supply, sewage, and electricity, all of which rely on the same public infrastructure. The lack of inter-agency coordination and integrated planning has resulted in frequent road excavations and repairs, posing a major challenge to delivering high-quality, long-lasting roads.

Formation of the SOP Committee:

The Engineer-In-Chief of BBMP issued office order *BBMP/EIC/PR/654/2024-25* dated *19.11.2024* announcing the formation of the 'Experts Committee under the Chairmanship of Engineer-in-Chief, to evolve standard design and practices for road construction, development and maintenance of roads, preparation of the manual for road design and putting in place a Standard Operating Procedure (SOP) in BBMP limits'.

The SOP Committee meetings were held twice a month at IPP Center, Malleswaram, and occasionally in the BBMP Head Office, Hudson Circle, at the Chamber of the Engineer-in-Chief. The committee invited several domain experts and representatives of government agencies when formulating this document. The committee also reviewed existing literature, particularly reports published by BBMP, 'Guidelines for Construction and Maintenance of City Roads - 2009' by K.N. Shivashankara Rao, Chief Engineer (Retd), PWD, GoK, Member, TAC, BBMP and 'Standard Bidding Documents' and 'Standard RFP for Maintenance' document and the tender for approx. 400 kms of roads at the budget of Rs. 694 Crores which prescribed comprehensive guidelines and technical specifications in all aspects of road development and maintenance, based on IRC and other relevant manuals and codes.

A. BACKGROUND

Summary of Committee Work:

- The committee undertook a comprehensive review of existing systems and processes involved in road development and maintenance, aiming to assess their effectiveness and identify areas for improvement. This involved an in-depth study of current practices, challenges, and coordination mechanisms among various agencies responsible for road infrastructure in the city.

- A key focus of the committee's work was to analyse successful road implementation projects and extract best practices that could be adapted to the local context. Special attention was paid to understanding the primary factors contributing to the premature deterioration of asphalt roads, particularly why many fail to last beyond the prescribed standards. By examining these underlying issues, the committee sought to pinpoint systemic inefficiencies and recurring challenges.

- In addition to assessing the status quo, the committee explored practical, implementable solutions that could enhance the durability and quality of road infrastructure, which includes not only the main carriageway but also other civil works related to footpaths, medians, and all underground utilities. It is the committee's opinion that BBMP must prioritize the quality and completion of civil works to increase the durability of the road itself.

- Parallelly, long-term reforms were identified to create a more resilient and well-coordinated road management framework. These reforms were aimed at improving inter-agency collaboration, ensuring quality control, and establishing sustainable maintenance practices. It is the committee's opinion that all road data, including historical data, must be digitized on a GIS-based platform and published to improve transparency, assist in future planning, and monitor expenditure.

- The findings and recommendations of the committee were compiled into the *Namma Raste Kaipidi*, a comprehensive document submitted to BBMP. This document serves as a roadmap for systematic improvements in road development and maintenance, emphasizing efficiency, longevity, and enhanced coordination among stakeholders.

The committee suggests that these recommendations be applied to a pilot of 100 km under the supervision of the committee. This can be called 'Namma Raste 100', to further improve and validate the SOP on the ground.

B. SOP COMMITTEE

Members of the Committee:

Sr. No.	Name and Profile of the Committee Member	Role
1.	**Dr. B S Prahallad, Engineer in Chief, BBMP** Masters in Highway Technology | PhD. in Asphalt Mixes	Chairman
2.	**M Lokesh, Chief Engineer (Central Projects), BBMP** Bachelors in Civil Engineering | Masters in Technology, Structures, IIT Madras	Member
3.	**Basavaraj R Kabade, Chief General Manager, BSWML** Bachelors in Civil Engineering | Masters in Technology, Transportation Engineering, IIT Madras	Member
4.	**Anand, Superintendent Engineer (Electrical), BBMP** Bachelors in Engineering, Electrical	Member
5.	**Prof. Dr. Ashish Verma, IISc** Bachelors in Civil Engineering | Masters in Transportation Systems Engineering | PhD in Transportation Systems Engineering	Member
6.	**Prof. V Sreenivas, IISc** Bachelors in Civil Engineering | Masters in Water Resource Engineering | PhD in Water Resource Engineering	Member
7.	**Prof. Anbazhagan, IISc** Bachelors in Civil Engineering | Masters in Geotechnical Engineering | PhD in Geotechnical Engineering	Member
8.	**Srinivas Alavilli, Senior Fellow, WRI India** Urbanist | BE & MS Computer Science	Member
9.	**Chetan Sodaye, Program Manager, WRI India** Bachelors in Architecture | Masters in Urban Design, CEPT University | Global Road Safety Leadership, Johns Hopkins Bloomberg School of Public Health | iRAP course for Helping Save Lives, iRAP & World Bank	Member
10.	**Amruta Sai, Deputy Chief Engineer (Road Infra)** Bachelors in Civil Engineering	Member Secretary

B. SOP COMMITTEE

Members of the Committee:

SOP Committee Members at IPP Center, Malleshwaram

Special Invitees:

Sr. No.	Name and Designation of the Member	Role
1.	**M N Anucheth, Joint Commissioner of Police (Traffic), Bengaluru**	Special Invitee
2.	**Dr. Furqan Bhatt, Post Doctorate, IISc**	Special Invitee
3.	**Naresh Narasimhan, MOD Foundation**	Special Invitee
4.	**Vijay Narnapatti, MayaPRAXIS**	Special Invitee
5.	**R K Mishra**	Special Invitee
6.	**Devraj, Chief Engineer, BWSSB**	Special Invitee
7.	**Rajeev, Chief Engineer, BWSSB**	Special Invitee
8.	**Karthik, Deputy General Manager, BESCOM**	Special Invitee

C. ACKNOWLEDGEMENTS

Committee Members in various SOP Committee Meetings

On behalf of WRI India, Indian Institute of Science (IISc), and members of the committee.

We extend our sincere gratitude to **Tushar Giri Nath, IAS, Chief Commissioner BBMP**, for establishing this committee and providing us with the opportunity to contribute to the city's development. We deeply appreciate the leadership and guidance of **Dr B. S. Prahallad, Engineer-in-Chief, BBMP**, whose extensive experience and insights into existing systems and processes were invaluable in identifying key areas of concern, consulting domain experts, and incorporating practical recommendations.

We would also like to express our appreciation to M Lokesh, Chief Engineer of (Projects Central), BBMP; Basavaraj R Kabade, Chief General Manager, BSWML; Naresh Narasimhan; R K Misra; Clement Jaikumar; and all the other esteemed members of the committee and special invitees for their expertise and unwavering support throughout this initiative.

Our heartfelt thanks go to Srinivas Alavilli, Chetan Sodaye, Krishna Priya Poroori, and Arnav Muralidhar of WRI India, as well as Prof Dr Ashish Verma and Dr Furqan Bhat of IISc Sustainable Transportation Lab, for their dedicated participation in meetings, research, documentation, and contributions to this document. We also extend our gratitude to Madhav Pai, Pawan Mulukutla, Dhawal Ashar, Anya George, Anindita Bhattacharjee, Sudharsan, and Gagana of WRI India for their continued support in this endeavour.

We sincerely appreciate the efforts of Bhagyashree Kulkarni and her team at MOD Foundation for developing the illustrated handbook accompanying this document. This initiative will play a crucial role in enhancing the capacity of BBMP engineers through innovative and engaging training methods.

Finally, we extend our gratitude to Amruta Sai, Deputy Chief Engineer, BBMP, for her commitment to convening committee meetings despite numerous challenges. We also acknowledge the invaluable support of Dhananjay, Executive Engineer BBMP; Balakrishna Shetty, AEE BBMP; and Shivaraju and Shishir from the office of the Engineer-in-Chief BBMP, as well as the staff at the IPP Centre, whose contributions ensured smooth functioning of the committee over the past three months.

ABOUT NAMMA RASTE KAIPIDI

		ROADS		SPECIAL AREAS		
IRC ROAD HIERARCHY	BBMP ROADS	JUNCTIONS	MIDBLOCKS (CORRIDOR)	SCHOOL ZONES	STATION AREAS	
Urban Expressways/ Arterial Roads	HDC	HDC Road Design Manual	HDC Road Design Manual	NA		HDC Manual
	PROJECT PLANNING	Tender SURE & Namma Raste Kaipidi				Namma Raste Kaipidi
Arterial/ Sub-Arterial/ Collector/ Local Roads	White Topping	Suraksha75 SOP & Namma Raste Kaipidi	Namma Raste Kaipidi	Namma Raste Kaipidi		
Arterial/ Sub-Arterial/ Collector/ Local Roads	Asphalting					
Collector Roads/ Local Roads	Ward Roads					
Local Roads	Ward Roads/ Conservancy Lanes					
	Operations And Maintenance	Tender SURE & Namma Raste Kaipidi				
Arterial/ Sub-Arterial/ Collector/ Local Roads	Tender SURE	Tender SURE	Tender SURE	NA		Tender SURE Guidelines
Arterial/ Sub-Arterial/ Collector/ Local Roads	Tender SURE Lite					

ABOUT NAMMA RASTE KAIPIDI

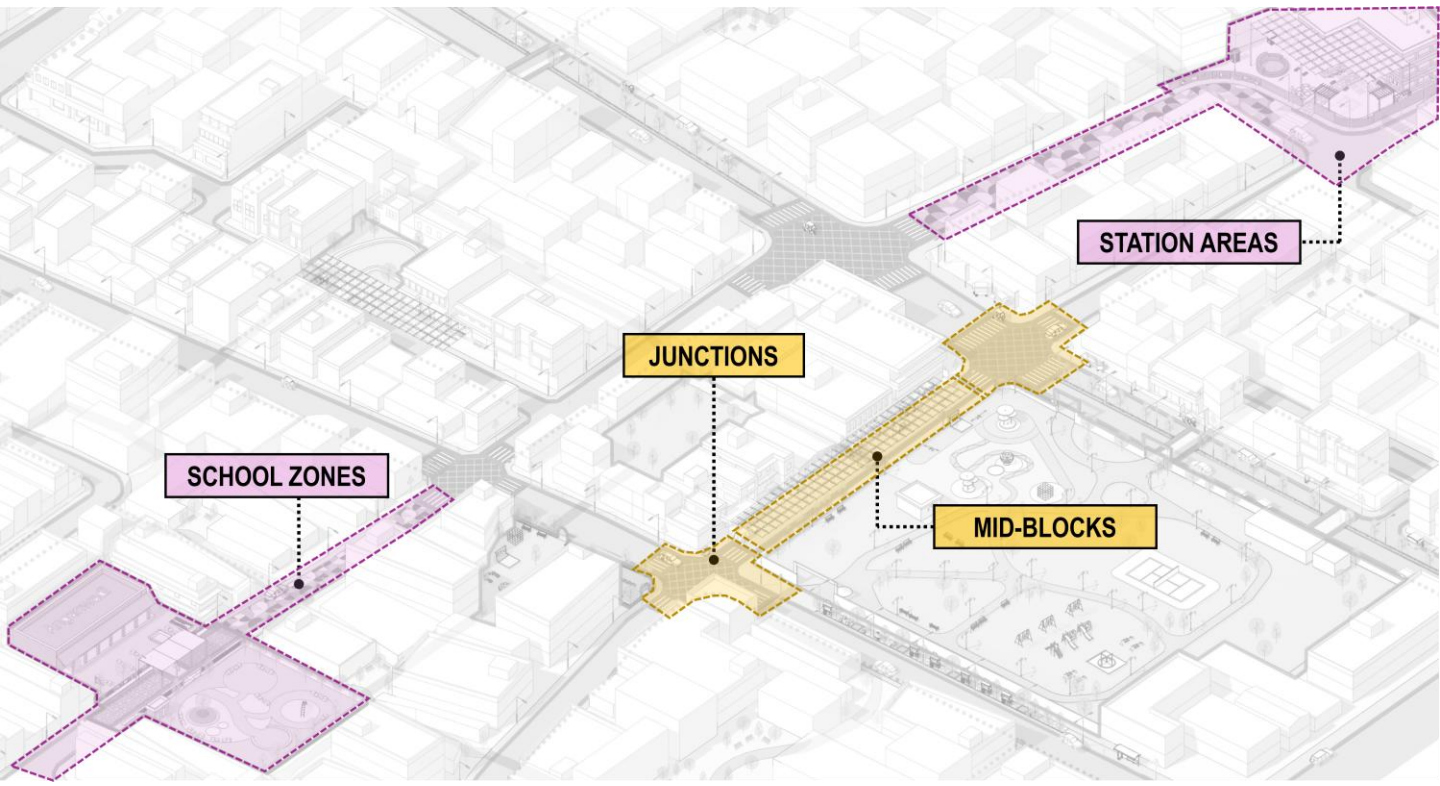
ROADS [BBMP Ward Roads]

JUNCTIONS

Types of junctions, components of a junction, design elements to make junctions safer for pedestrians

MID-BLOCKS

Types and components of corridors, design of public spaces, blue-green infrastructure and appropriate materials



SPECIAL AREAS

SCHOOL ZONES

Design for drop-off zones, Placemaking guides including play elements and street furniture for children safety

STATION AREAS

Design for better last-mile, bus stops, IPT, on-street parking and Multi-Utility Zones including vending zones

Graphics: WRI India

D. SUMMARY OF KEY COMMITTEE RECOMMENDATIONS

All the key recommendations have been compiled and collated into the following three sections:

PROJECT PLANNING | **DESIGN AND ENGINEERING** | **OPERATIONS AND MAINTENANCE**

1. **Centralized Data Hub**: The committee suggests to maintain an inventory of all road works (road history) through a dynamic dashboard to ensure coordination between all stakeholders involved including BBMP, BTP, BWSSB and BESCOM. The dashboard could be a part of the existing ICCC portal. It could facilitate a data driven approach to prioritizing and identifying projects, ensure transparency and equitable distribution funds for road projects. The dashboard will keep all agencies and the public informed about ongoing projects in their jurisdiction and neighborhood.

2. The committee recommends granting **BBMP Executive Engineers greater budget approval authority** since doing so could facilitate timely contractor payments and expedite the process for increased efficiency.

3. The committee recommends creating an **inventory of contractors** with outstanding liabilities or incomplete projects. When awarding new projects, contractors with pending work are suggested to be given lower priority. Additionally, the **subcontracting process** is to be defined clearly and reviewed regularly to ensure high-quality work.

4. Whenever a project is proposed and DPR is prepared, the committee recommends that the **draft tender and be shared with all stakeholders** (BTP, BWSSB, BESCOM) to keep them informed and get their inputs and approval. This will ensure smooth implementation of the project and its longevity.

5. In areas where comprehensive development is not undertaken, the committee recommends **separating or delinking civil works** (e.g. footpaths, drains and medians) from road resurfacing works. Combining both often compromises the attention that civil work requires. However, it is to be noted that it is essential to **complete all civil works before commencing road resurfacing** to ensure high-quality infrastructure and avoid incomplete works.

6. The committee recommends **onboarding of consultants with design expertise** for the design and implementation of road development projects. The consultants are suggested to carry out studies and condition assessments, traffic assessments, analysis of rainfall and hydrology data, geotechnical surveys, etc. based on the need and propose holistic designs based on site conditions.

7. The committee recommends **updating the schedule of rates (SR) and materials** to align with market standards and incorporate modern materials, street furniture, street lighting, etc. The current SR and materials limit innovation in street design.

8. The committee suggests **improving road safety** across all corridors and junctions in the city to ensure safety of all road users, both during implementation and post implementation.

D. SUMMARY OF KEY COMMITTEE RECOMMENDATIONS

PROJECT PLANNING | DESIGN & ENGINEERING | OPERATIONS AND MAINTENANCE

9. Effort must be taken to carry out comprehensive mapping, including for the location, alignment, size, and newly laid lines, if any. Doing so will ensure efficient design of utilities and implementation of ongoing and future projects.

10. After following the above process, approvals for road cutting should be requested through the Multi-Agency Road Cutting Coordination System (MARCS) for all types of work, including optic fiber cabling. The committee recommends **enhancing the MARCS approval process**. Additionally, the responsibility for restoring cut roads must be defined clearly, and a structured restoration process should be established.

11. The committee recommends **increasing the number of BBMP engineers**, as staff shortages result in inefficiencies in supervision and work monitoring.

12. The committee suggests that **capacity building workshops and** technical sessions be conducted every 90 days for BBMP engineers, contractors, and project management consultants to disseminate the proposed new processes, methods, and techniques of road design, construction, and maintenance.

13. The committee recommends **leveraging social media** to highlight quality infrastructure projects in the city and to engage with the public. Additionally, mechanisms to **incentivize good quality work** need to be identified.

14. The committee suggests regular **stakeholder engagements and public participation** during the planning stage to understand their needs and issues to be addressed. Engagements with the community including disability rights groups, senior citizens, parents of young children, and other stakeholders are suggested to be carried out to understand accessibility needs.

15. The committee recommends taking up **comprehensive development of roads** wherever possible, including the design and construction of footpaths, pedestrian-friendly infrastructure and utilities (construction of stormwater drains and upgrading/ restoring/ shifting of utilities) wherever necessary. This holistic development aims to minimize road cutting and rework in the near future thereby ensuring efficiency of road infrastructure projects.

16. In addition to asphalting and white topping, the committee recommends considering **other road laying materials/ techniques like Stone Matrix Asphalt (SMA) and microsurfacing**. It is recommended to **test pilots and scale** the usage of materials based on performance. Additionally, given the movement of heavy vehicles on ward roads, the committee recommends considering construction of both **BC and DBC layers on ward roads**, similar to the approach used for arterial and sub-arterial roads.

17. The committee recommends the institutionalization of **asphalt milling**, making it a mandatory and strictly enforced practice to enhance the longevity of newly laid roads.

D. SUMMARY OF KEY COMMITTEE RECOMMENDATIONS

PROJECT PLANNING | DESIGN & ENGINEERING | OPERATIONS AND MAINTENANCE

18. The committee recommends shifting the process of laying of roads to morning since night asphalting minimizes disturbances but compromises on the quality and efficiency of the road laying process due to lack of sufficient monitoring. It is therefore recommended to carry out asphalting during the daytime, let the asphalt set overnight and keep the road closed to traffic until the asphalt surface temperature drops to 30°C. To achieve the same, traffic management plans are to be created together with BTP, detailing alternate routes and work schedules need be planned to minimize disruptions. The same is suggested to be notified to the residents of the neighborhood via mobile VMS.

19. The committee recommends designing stormwater drains based on site-specific conditions, taking into account rainfall, runoff data etc. It is also suggested that the drains include vertical gratings or chambers with silt traps to prevent clogging. The committee recommends replacing stormwater box drains with hume pipes owing to itself cleansing scouring velocity that results in reduced silting.

20. The committee suggests considering implementation of third-party quality audits to evaluate road quality at every construction phase. Independent auditors must adhere to IRC standards and verify materials, processes, and outcomes. Periodic quality checks and monitoring to be mandated to ensure optimal quality of material used, including monitoring at batch plants. To ensure accountability and traceability, comprehensive documentation and reporting of all test results are recommended.

21. The committee recommends mandating the submission of handover documentation by contractors including ‘as-built drawings’, an operating and maintenance manual and sign-off sheets from all stakeholders at the end of each project.

22. It is suggested to define clear criteria for a project's completion and establish a standardized project completion checklist. This checklist is suggested to be completed by the AEE/EE at the end of each project to ensure compliance and accountability.

23. The committee recommends the creation of a dedicated Road Maintenance Cell within BBMP with representation from all relevant agencies and service providers. The cell can support site inspections, quality checks, coordination in repair works, coordination with all stakeholders involved including citizen groups etc.

24. The committee recommends conducting an annual assessment of road infrastructure quality. These evaluations can help early detection of defects like sinkhole formation, particularly in the case of white-topping and other issues that require attention.

25. The committee recommends the development of improved road maintenance models, designating a single agency responsible for road maintenance (including cleaning and waste disposal) at the ward level. A similar approach should be applied to stormwater drains, ensuring they are regularly desilted before and after each rainfall.

The committee recommends piloting the suggested best practices on a network of roads to understand their effectiveness and performance before scaling up to all 12,000+ kms of BBMP roads.

01 PROJECT PLANNING

1. PROJECT PLANNING

Streamlining the Project Outline and Vision

Once a project is identified, it is crucial to establish its intent and necessity through a well-defined Project Outline and Vision. This step ensures that all stakeholders have a common understanding of the goals, scope, and expected outcomes. Clearly defining the project vision helps in setting priorities, aligning resources, and ensuring that interventions address the most pressing urban mobility and infrastructure challenges.

The identified works can fall under one of the following categories:

1. **Network of Streets** – This includes an interconnected system of roads requiring holistic improvements to enhance accessibility, mobility, and infrastructure quality across a larger urban area. Planning at this scale ensures seamless integration of pedestrian, cycling, and vehicular infrastructure.
2. **Cluster of Multiple Discontinuous Streets** – This involves improvements to multiple streets that may not be contiguous but serve an interconnected purpose in the urban transport ecosystem. Addressing these streets collectively can lead to uniformity in urban design, traffic flow efficiency, and better last-mile connectivity.
3. **Cluster of Junctions** – This focuses on multiple junctions that require simultaneous interventions for improved traffic management, pedestrian safety, and multimodal integration. Junction-level improvements can significantly reduce congestion, accident risks, and delays.
4. **Single Street or Junction** – This involves targeted improvements to a specific road segment or intersection where challenges suhc as pedestrian safety, traffic bottlenecks, or inadequate infrastructure need resolution. This approach is useful for quick-impact interventions or pilot projects before scaling up to city-wide improvements.

Project Intent and Scope

The project should have a clearly defined intent to ensure that interventions are systematic, effective, and aligned with broader urban development goals. The scope of work can be classified into the following categories:

1. Comprehensive Development (Surface – Level and Sub-Surface Improvements)

A holistic approach integrating both above-ground and underground infrastructure improvements for long-term urban resilience.

- **Integrated Street Design:** Combining pedestrian, cycling, and vehicular infrastructure to create a balanced and inclusive streetscape.
- **Sustainable Drainage Systems:** Incorporating stormwater management solutions like bioswales, permeable pavements, and rainwater harvesting to prevent flooding.
- **Smart Infrastructure Integration:** Implementing smart poles, traffic management systems, and underground utility corridors to future-proof urban streets.

2. Development of Footpaths (Geometric Improvement, Pavement Improvement)

Enhancing pedestrian infrastructure to ensure accessibility, safety, and a better urban experience.

- **Universal Accessibility:** Incorporating tactile paving, ramps, and barrier-free pathways for people with disabilities and senior citizens.
- **Street Furniture & Amenities:** Adding benches, shaded areas, lighting, and public art to improve walkability and user experience.
- **Integration with Public Transport:** Designing footpaths that connect seamlessly with bus stops, metro stations, and last-mile mobility options.

3. Utilities Improvement (Sub-Surface Level Improvements)

Enhancing underground infrastructure to support sustainable urban growth and reduce frequent road disruptions.

- **Underground Ducting for Utilities:** Organizing power, telecom, water supply, and sewage in designated underground ducts to prevent frequent digging.
- **Leakage and Waste Management Solutions:** Implementing sensor-based monitoring for water leakages and improving waste disposal mechanisms.
- **Disaster-Resilient Infrastructure:** Strengthening underground infrastructure to withstand extreme weather conditions and reduce service disruptions.

4. Improvement in Carriageway (Geometric and Pavement Improvement)

Upgrading road design and surface quality for safer and more efficient vehicle movement.

- **Optimized Lane Markings and Road Geometry:** Implementing proper lane discipline, channelization, and optimized intersection design to improve traffic flow.
- **High-Quality Pavement Materials:** Using durable materials like bituminous concrete or white-topping to enhance road lifespan and minimize maintenance needs.
- **Traffic-Calming Measures:** Introducing speed humps, raised crossings, and lane narrowing techniques to improve road safety and reduce accidents.

Identifying the Location and Extent of Works

The finalized project needs to have GIS-based mapping of the streets or junctions' network, as well as a map of the area impacted by this improvement. All the stretches and points shall have a unique ID to be mapped in the ICCC for centralized mapping of ongoing and completed works.

Once the locations are identified, they need to be cross-checked for any overlapping works or Defect Liability Period (DLP) for avoiding duplication of works.

1. PROJECT PLANNING

Dynamic Dashboard:

All projects undertaken for road improvements shall be recorded on a regular basis in the ICCC portal. The idea is to have a dynamic dashboard that allows tracking of works under BBMP and other stakeholders carried out on BBMP-owned roads as a start. This will include previously executed works, ongoing works, proposed works and laying of utilities by other agencies such as BESCOM and BWSSB.

Strengthening the Request for Proposal for an Improved DPR and Project Implementation

A well-defined Scope of Work and Budget Allocation serve as the foundation for drafting a comprehensive and precise Request for Proposal (RFP). This, in turn, directly influences the quality of the Detailed Project Report (DPR) and the effectiveness of project execution. By ensuring that the RFP is meticulously structured, engineers can facilitate the preparation of an accurate, data-driven DPR, leading to an efficiently executed and well-implemented project.

Scope of Work

Following the identification of the project outline and location, it is imperative to establish a well-defined Scope of Work that delineates the responsibilities of all stakeholders. This ensures that all aspects of planning, design, execution, and oversight are comprehensively addressed. The scope is categorized into the following key components:

1. Scope of Work for the DPR (Detailed Project Report) Consultant

The DPR Consultant is responsible for developing a technically sound and financially feasible DPR, which serves as the guiding document for project execution. Clearly defining the consultant's scope within the RFP ensures the development of an implementable and outcome-oriented DPR.

- **Site Assessment and Data Collection:** Conducting detailed topographical, geotechnical, and traffic surveys to analyse existing conditions and infrastructural gaps.
- **Conceptual Design and Feasibility Study:** Proposing multiple design alternatives, including road cross-sections, junction layouts, pedestrian infrastructure, and utility corridors.
- **Cost Estimation and Financial Analysis:** Preparing a detailed cost breakdown, lifecycle cost assessment, and financial feasibility study to optimize resource allocation.
- **Stakeholder Engagement:** Coordinating with urban local bodies, government agencies, and community stakeholders to incorporate feedback and ensure adherence to planning norms.

A well-defined scope for the DPR Consultant in the RFP ensures that the final report is comprehensive, aligned with project objectives, and technically sound, thereby minimizing the need for revisions during execution.

2. Scope of Work for PMC (Project Management Consultant)

The Project Management Consultant (PMC) plays a critical role in ensuring that the project is executed in accordance with the approved DPR, maintaining quality, efficiency, and adherence to the specified timeline. Clearly articulating the PMC's responsibilities in the RFP facilitates effective governance and oversight throughout the project lifecycle.

- **Bid Process Management and Contractor Selection:** Assisting in the preparation of tender documents, evaluating contractor bids, and ensuring a transparent procurement process.
- **Construction Supervision and Quality Control:** Conducting on-site inspections, verifying materials, and ensuring compliance with approved design specifications and safety standards.
- **Progress Monitoring and Risk Mitigation:** Tracking project milestones, identifying potential risks, and implementing mitigation strategies to prevent delays.
- **Interagency Coordination:** Liaising with urban local bodies, service providers, and regulatory authorities to streamline approvals and ensure seamless execution.

A clearly defined PMC scope in the RFP enhances project accountability, ensures adherence to quality benchmarks, and facilitates efficient coordination, thereby contributing to the timely and successful delivery of the project.

3. Scope of Work for Implementation

The implementation phase focuses on translating the DPR into on-ground execution, ensuring that construction activities are carried out in strict alignment with design specifications and stakeholder expectations. Establishing a clear and structured implementation scope within the RFP is essential for ensuring operational efficiency and minimizing execution challenges.

- **Preliminary Works and Utility Shifting:** Coordinating with service agencies for the shifting of underground utilities (water pipelines, electrical cables and telecommunications) prior to construction activities.
- **Construction and Civil Infrastructure Development:** Executing roadway improvements, footpath development, junction reconfiguration, and installation of street infrastructure.
- **Traffic Management and Safety Measures:** Implementing temporary traffic diversions, installing appropriate signage, and ensuring pedestrian safety during construction.
- **Post-Construction Inspection and Handover:** Conducting quality audits, addressing any defects, and obtaining requisite approvals before the project is made operational.

Clearly articulating the implementation scope in the RFP ensures that the project progresses smoothly, efficiently, and in full compliance with the DPR, thereby enhancing the quality and longevity of the infrastructure.

1. PROJECT PLANNING

Establishment of a Design and Estimate Scrutiny Committee in BBMP

A structured **Design and Estimate Scrutiny Committee is proposed within BBMP** to streamline project approvals, ensure design standardization, and enhance financial prudence. This initiative aims to establish a systematic review mechanism for urban infrastructure projects, ensuring technical soundness and equitable allocation of resources.

As per the recommendation of the EIC, taking example of Chennai, where project design approvals from consultants are routed to CE Design in Chennai for scrutiny. However, in Bengaluru, the proposed Design Committee/Scrutiny Committee will be **chaired by Chief Engineers** (CEs), **with different CEs presiding over the committee on a rotational basis**. The committee will function as an institutionalized body for reviewing project designs and cost estimates, strengthening the overall project implementation framework within BBMP.

To improve efficiency, all estimates will be submitted electronically, ensuring transparency and accountability in the approval process. Additionally, a **minimum of two formal consultations per project** will be mandated, facilitating thorough deliberation and informed decision-making before final approvals.

Responsibilities of the Committee:

1. **Road Infrastructure Inventory & Equitable Fund Allocation**

- Developing and maintaining a comprehensive inventory of roads across the city to facilitate data-driven decision-making.
- Ensuring equitable distribution of state funds, preventing resource concentration in specific areas, and enabling balanced urban development.
- Identifying priority projects based on factors such as traffic volume, existing road conditions, safety requirements, incomplete networks in the city outskirts and future urban mobility needs.

2. **Project History & Developmental Works Review**

- Assistant Executive Engineers (AEEs) or Assistant Engineers (AEs) will be required to present a detailed history of developmental works undertaken for identified roads.
- This will include previous interventions, asset conditions, budgetary allocations, and pending works, ensuring continuity and avoiding redundant expenditures.
- The review process will ensure that project proposals align with long-term urban mobility goals, adhering to city-wide planning frameworks.

Integrating these measures into BBMP's urban project governance framework will enhance the efficiency, transparency, and sustainability of road development initiatives across Bengaluru.

1. PROJECT PLANNING

Budget Allocation

A well-structured budget is integral to the **development of a precise and financially viable RFP**, preventing cost overruns and ensuring efficient resource utilization. The budget should be formulated based on the **Project Outline, Extent of Works, and Scope of Work**, incorporating the following considerations:

- **Standardized Costing Framework:**
    - Rate per **kilometre** for **road corridors**, considering surface materials, geometric enhancements, and integrated infrastructure.
    - Rate per **square meter** for **junctions**, factoring in pedestrian accessibility, signalization, and traffic-calming measures.
- **Material and Resource Costing:**
    - Comprehensive cost assessment for raw materials, labour, equipment, and sustainability-driven infrastructure components.
- **Contingency Provisions and Inflation Adjustments:**
    - Allocating contingency reserves to account for unforeseen expenses such as design modifications, material price fluctuations, and unexpected site conditions.
    - Adjusting for cost escalations due to inflationary trends and external economic factors.
- **Exploration of Funding Mechanisms:**
    - Identifying **potential budgetary allocations** from **state and national government programs**, including the **Smart Cities Mission, Urban Transport Initiatives, and Road Safety Programs**.
    - Assessing **alternative funding sources**, including public-private partnerships (PPP), corporate social responsibility (CSR) initiatives, and grants from multilateral agencies.

A **well-defined budget allocation framework in the RFP** ensures **financial transparency, enables realistic DPR development, and optimizes funding utilization**, thereby enhancing project feasibility and execution efficiency.

Payment Model

Every project should have its own mechanism for the payment structure, bifurcation and regulatory authority. These may differ based on the scale of the project. The following was discussed to provide more power to Executive Engineers, as well as allow for faster payments:

- **Small-to-medium scale projects** (usually identified by the budget or cost of the project) shall have their review at the scale of Executive Engineers.
- **Large-scale projects** (usually identified by the budget or cost of the project) shalle have their review at the scale of Chief Engineers.

- **Large-to-Mega Scale projects** (usually identified by the budget or cost of the project) shall have their review at the scale of Chief Engineers, Spl. Commissioner or Commissioner.

Definitions of small, medium, large and mega scale projects need to be defined in unison by the BBMP, GoK and any other relevant stakeholders. Once it is defined, this process will need to be followed for projects at all its stages: from RFP to DPR to implementation to monitoring and maintenance.

Strengthening the RFP as the First Step Toward a Well-Executed Project

A meticulously crafted RFP serves as the foundation for a robust DPR, which in turn ensures a well-implemented project. The structured approach outlined above contributes to the following:

- **Enhanced DPR Quality:** A clearly defined scope in the RFP enables DPR consultants to develop technically sound and implementable solutions, reducing scope creep and delays.
- **Optimized Resource Allocation:** A well-articulated scope and budget framework facilitate accurate cost estimation, preventing financial shortfalls or excess spending.
- **Efficient Project Execution:** A precise RFP leads to better contractor selection, streamlined oversight, and minimized execution challenges, ensuring timely project completion.
- **Improved Urban Infrastructure Outcomes:** The final project delivering safer, more resilient, and better – designed public spaces by strengthening the early-stage planning process.

By prioritizing a well-structured RFP, engineers and planners lay the groundwork for an efficient and effective urban development process, ultimately enhancing the quality and impact of mobility and infrastructure projects.

Road Safety and Safe Systems Approach

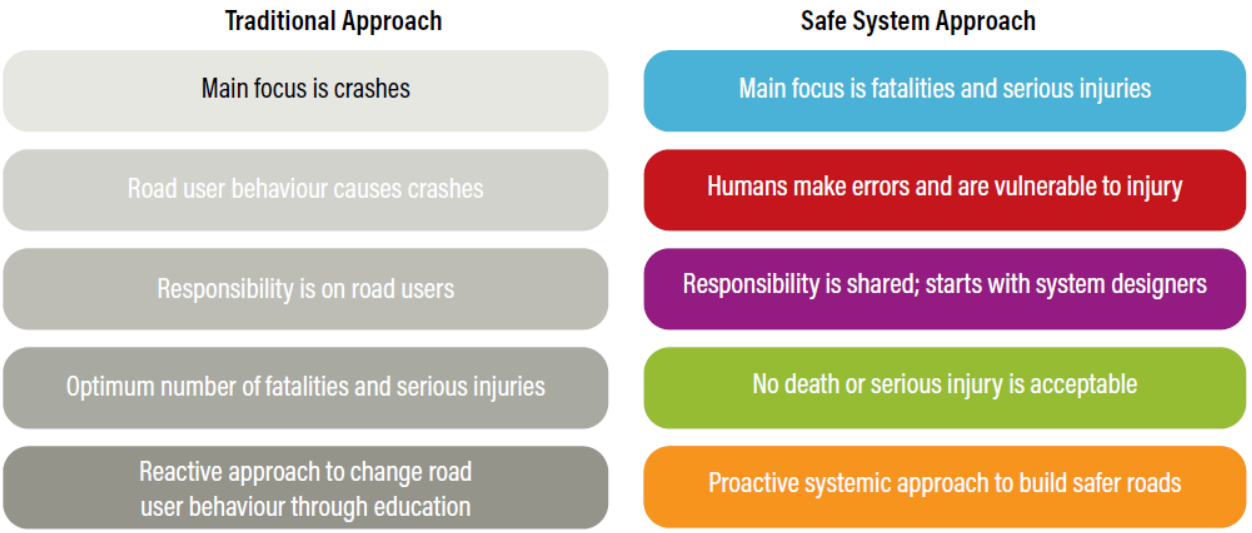
The Safe System approach recognizes road safety as the outcome of the interaction between many components that form a dynamic system that influences the way people travel and behave on the roads and thus their level of exposure to the risk of a collision. While this system ensures a high level of safety, it also brings numerous broader societal benefits, including improved accessibility, physical activity, air quality, climate change mitigation, and environmental sustainability, all of which contribute to overall public health.

The Safe System approach is based on the notion that humans are fallible, and errors are to be expected.

The principles of a Safe System are drawn from the principles in the report published by the International Transport Forum of the OECD (OECD/ITF 2015).

1. People make mistakes that can lead to road crashes.
2. The human body has a limited ability to tolerate crash forces before harm occurs.
3. A shared responsibility exists among the people who design, build, manage, and use roads and vehicles and provide post-crash care to prevent crashes that result in serious injury or death.
4. A proactive approach should be taken to making the mobility system safe, rather than waiting for events to occur and reacting. All parts of the system must be strengthened to multiply their effects, so that if one part fails, road users are still protected.
5. No death or serious injury should be accepted in the mobility system. Lack of safety should not be a trade-off for faster mobility. Rather, the mobility system should be both safe and efficient.

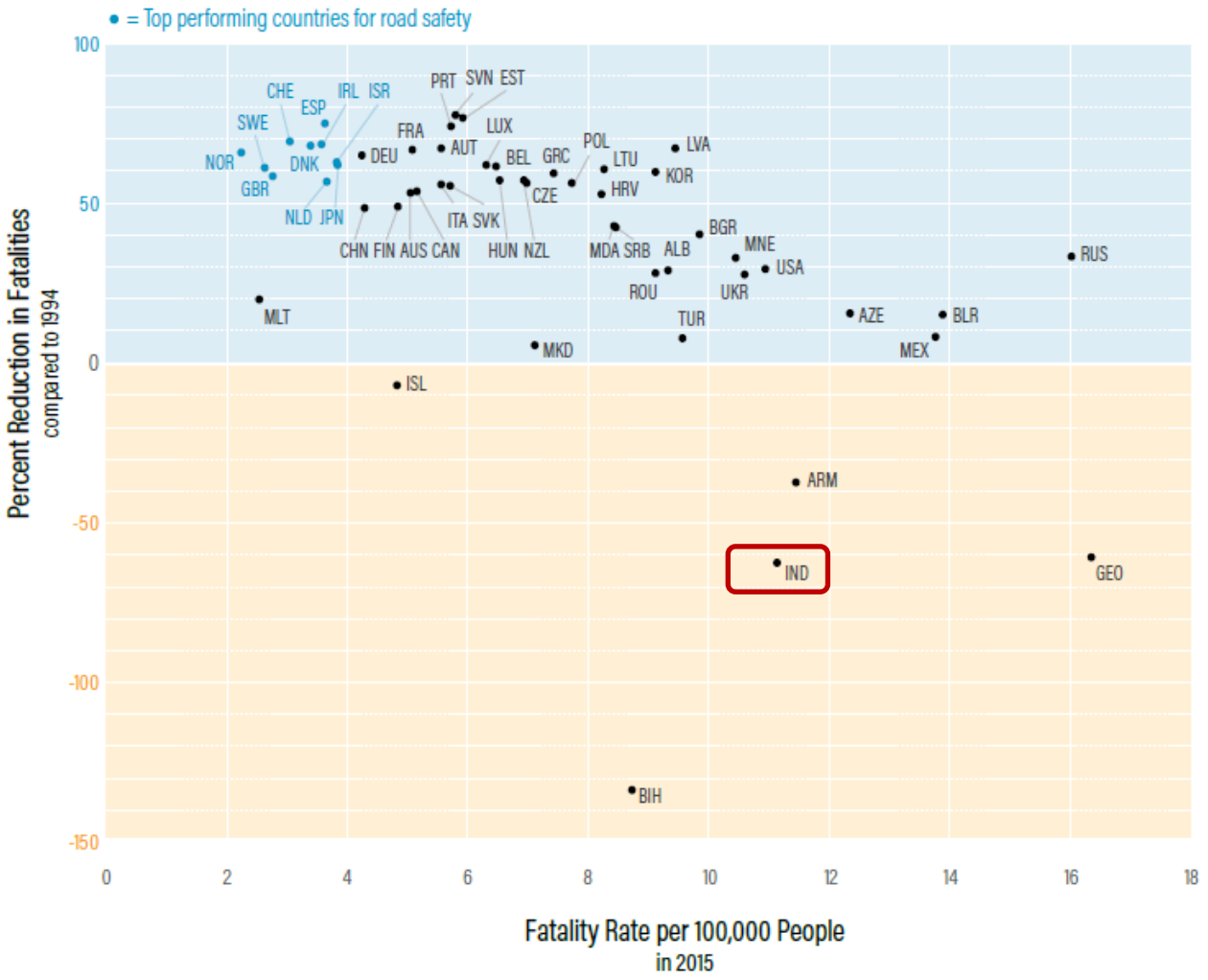
Comparison between Traditional and Safe System Approaches to Road Design



Sources: Belin 2015; Belin et al. 2012; Welle et al. 2018.

Many countries, states, and cities that have implemented the Safe System approach have achieved a faster reduction in road fatalities compared to those following traditional methods. According to the International Traffic Safety Data and Analysis Group (IRTAD - the traffic safety data arm of the OECD and the International Transport Forum), the number of road fatalities declined 42 percent between 2000 and 2013 in the 32 countries in IRTAD for which data are available (OECD/ITF 2015). IRTAD concludes that this overall good performance reflects "the implementation of systematic road safety strategies and programs."

The World Resources Institute (WRI) conducted additional analysis of traffic fatalities in 53 countries between 1994 and 2015. It revealed that countries that have adopted a Safe System approach have both the lowest rates of fatalities per 100,000 inhabitants and the fastest rate of change in fatality levels.



COUNTRY CODES:

ALB = Albania	CRO = Croatia	HUN = Hungary	MDA = Moldova	ROU = Romania
ARM = Armenia	CZE = Czech Republic	IND = India	MEX = Mexico	RUS = Russia
AUS = Australia	DEU = Germany	IRL = Ireland	MKD = Macedonia	SRB = Serbia
AUT = Austria	DNK = Denmark	ISL = Iceland	MLT = Malta	SVK = Slovakia
AZE = Azerbaijan	ESP = Spain	ISR = Israel	MNE = Montenegro	SVN = Slovenia
BEL = Belgium	EST = Estonia	ITA = Italy	NLD = Netherlands	SWE = Sweden
BGR = Bulgaria	FIN = Finland	JPN = Japan	NOR = Norway	SWZ = Switzerland
BIH = Bosnia and Herzegovina	FRA = France	KOR = South Korea	NZL = New Zealand	TUR = Turkey
BLR = Belarus	GBR = Great Britain	LTU = Lithuania	POL = Poland	UKR = Ukraine
CAN = Canada	GEO = Georgia	LUX = Luxembourg	PRT = Portugal	US = United States
CHN = China	GRC = Greece	LVA = Latvia		

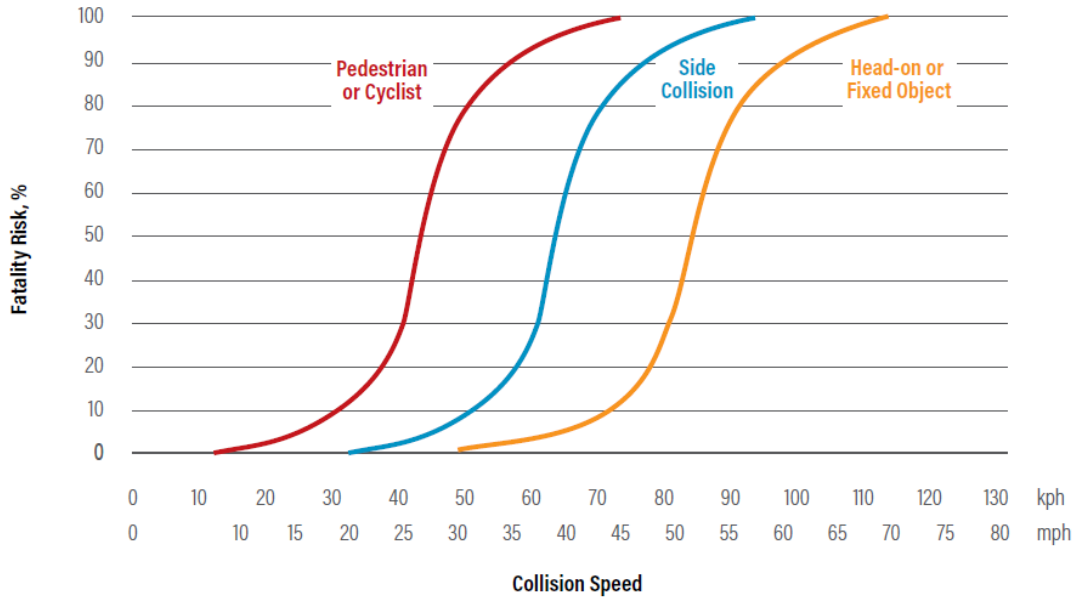
Source: WRI, based on data from OECD 2017.

Aligning the Safe Systems approach across all governmental levels can significantly increase its impact. Doing so usually involves a national plan or policy and complementary subnational policies at the state or provincial, regional, and city levels and this document outlines some strategies that can help achieve the same.

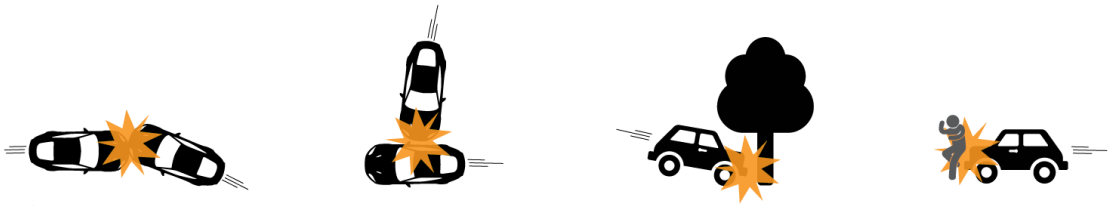
Speed Management

Speed determines the severity of crashes and injuries. It also affects the potential to avoid a crash, because higher speeds reduce drivers' capacity to stop in time, reduce maneuverability in evading a problem, make it harder to negotiate curves or corners, and cause others to misjudge the timing of approaching vehicles (Job and Sakashita 2016b).

Even small increases in speed result in significant increases in risk. Nilsson's (2004) meta-analysis of the relationship between speed and crash risk finds that for every 1 percent increase in speed there is a 4 percent increase in fatal crashes. Speed management is increasingly recognized as a key mechanism for road safety (Mooren et al. 2011). Speed can be managed through many elements of the system, including sound road design and management, appropriate speed limits, speed limit regulation, and education on the impacts of vehicle speed (GRSP 2008). Speed also determines the level of safety features and physical separation between road users required in the transport system.



Source: Wramborg (2005).



Risk of Head-on Crash
70≤km/h

Risk of Crash at Intersections
50≤km/h

Risk of Crash with Obstacles
60≤km/h

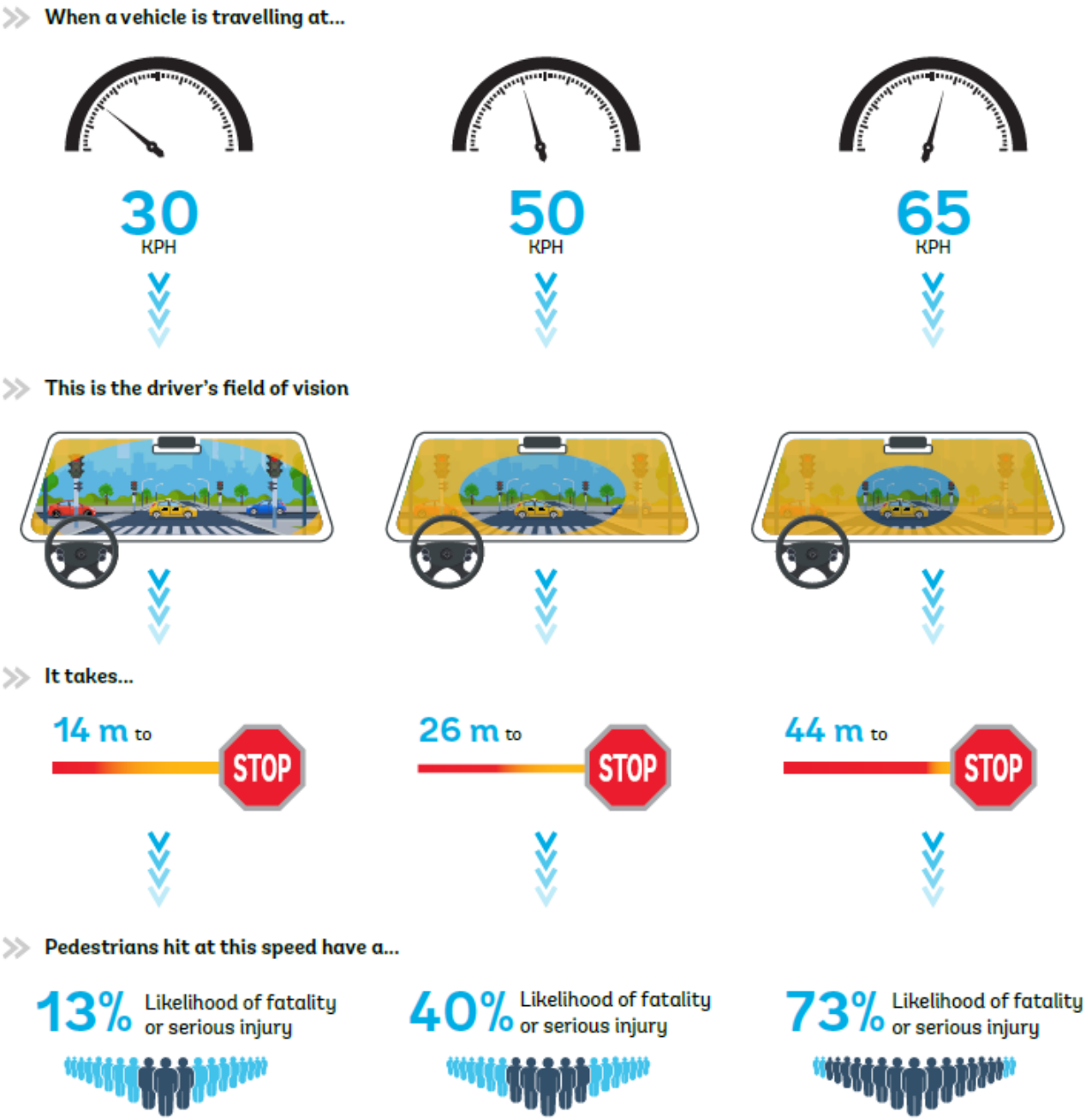
Risk of Crash with Vulnerable Road Users
30≤km/h

Source: Vadeby 2016.

It is therefore important to manage speeds on urban roads, rural roads and highways to levels that favor the probability of survival in the case of a collision, considering the possibilities of side-impact, head-on, and off-road crashes (above figures). This document details design strategies to limit driving speeds to the safe speed limit, through features such as speed humps, crossings raised to pedestrian level, road narrowing etc.

Higher speeds minimize the time drivers have to process information, make informed decisions and react. They increase the time it takes for a vehicle to stop upon braking, and worsen the impact of a collision, especially on the receiver's end. Driving at very high speeds can result in tunnel vision and decreased depth perception for the driver. At lower speeds, drivers have a wider field of vision and are more likely to notice other road users (refer to the figure below).

The figure below shows the influence of speed on the driver's field of vision, stopping distance, and road safety. As speeds increase, the field of vision narrows, which increases the likelihood of fatalities or serious injuries.



Source: Low-Speed Zone Guide. WRI & GRSF, 2021.

Note: Other sources indicate that the effects on pedestrian fatality and serious injury are even higher.

The Roads-for-Life Framework

The Roads-for-Life (R4L) framework is based on the Safe System approach and draws upon key elements of the Movement and Place philosophy. It recognizes that roads move both people and goods and serve as destinations in their own right. It points out that these two demands are often in conflict.

To optimize the movement of people and goods, roads should minimize travel time and allow people and goods to keep moving. In contrast, as places where people congregate for other activities, roads should be safe and attractive.

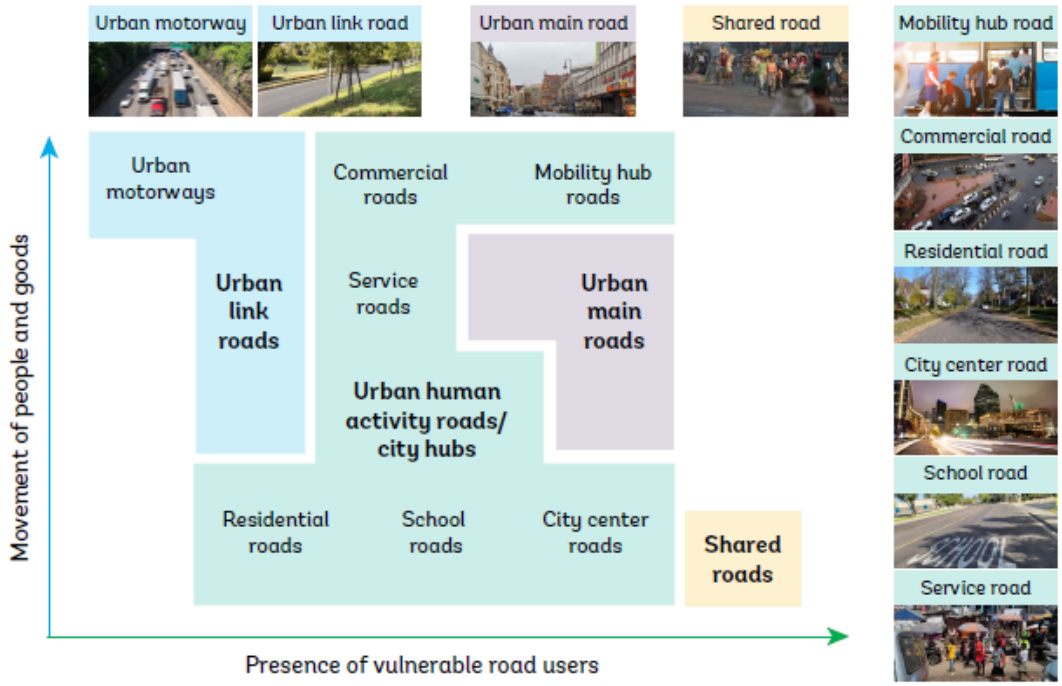
Unlike traditional functional road classification approaches, the R4L framework takes into account the movement and activity needs of VRUs such as pedestrians and cyclists using the road, children playing or people shopping in markets on the roadside. The R4L framework makes this possible by translating these concepts into a practical structure for classifying roads and setting safe speed limits. It identifies the purpose of a road in a way that allows safety for all types of road users and balances their needs across the road network. Accordingly, the speed setting process considers the priorities of different travel modes, roads and contexts, and the best outcomes for walking, cycling, and place-making as well as driving.

The main differences between many of the traditional functional road classification approaches and this new framework are summarized in the table below. This comparison highlights some of the shortcomings with the current approaches and the benefits from using this new framework.

Setting speed limits based on traditional functional road classification (left) versus setting speed limits based on the Roads-for-Life framework (right)

Traditional functional road classification approaches…	The Roads-for-Life framework…
…define the function of a road based on its hierarchy and set limits based on motorized traffic flow with limited consideration for vulnerable road users and land use context.	…classifies the road or road section based on the vulnerability of all road users, sets speed limits based on Safe System survivable impact speeds and considers that roads must both move people and goods and be attractive places for vulnerable road users.
…classify roads and determine speed limits and road design for the whole road segment regardless of changing road user needs and context ("A highway is always a highway").	…varies the road classification and speed limit for each section of any road depending on the context, or how the road is being used there. It recognizes that, because conditions and road user needs can change along a single road, its classification and speed limit should too.
…design roads for the typical or predominant motorized road users.	…designs roads and road sections for the most vulnerable road users, usually pedestrians and/or cyclists.
…react to speed-related crashes and take an incremental approach to reduce the problem.	…proactively targets and treats speed-related risks using a systematic approach to build a safe road system.

Roads-for-Life framework for selecting safe speed limits for urban roads or road sections. This figure includes a matrix of urban road types in relation to their demands and a table with corresponding recommended speeds



Type of road or road section and description	Safe speed limit
Shared road	
Road space where pedestrians and other vulnerable road users use the same road space as motorized vehicles; including road spaces within schools, hospitals, nursing homes or similar social infrastructure	Max. 10kph
Urban human activity road/city hub	
Road space where people gather, live, play and/or work on/next to the road and where people are likely to cross	Max. 30 kph
Urban main road	
Road space which provides mobility and connects with the wider transport network, while accommodating for a high presence of vulnerable road users, on-road activity and public life	Max. 30 kph - 50 kph*
Urban link road	
Road space which provides mobility for people and goods between major strategic centers with the highest motorized traffic volumes and longest trip lengths where presence of VRUs is not expected or minimal. If VRUs are present, the maximum speed will be 50kph and they must be protected from motorized traffic (e.g., by adequate sidewalks, cycling lanes, safe, at grade and signalized pedestrian crossings). Higher speeds can be in place only for urban motorways where VRUs are prohibited and directed to separate attractive facilities.	Max. 50 kph - 70 kph Max. 80 kph

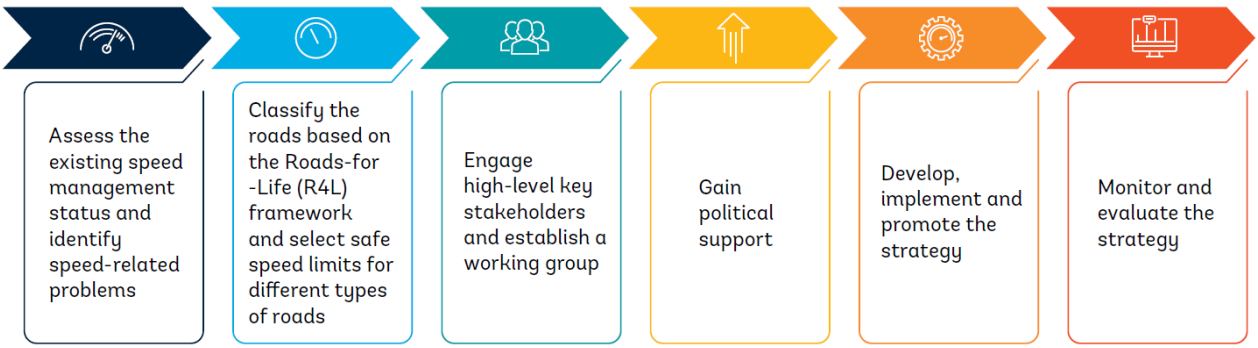
* Speed limits higher than 30 kph only for urban main roads with safe, adequate, and attractive provision for all vulnerable road users, including sidewalks/cycling paths with an adequate width and safe and adequately spaced crossing facilities.

Source: Guide for Safer Streets, WRI India and World Bank Group

1. PROJECT PLANNING

Developing a Speed Management Strategy

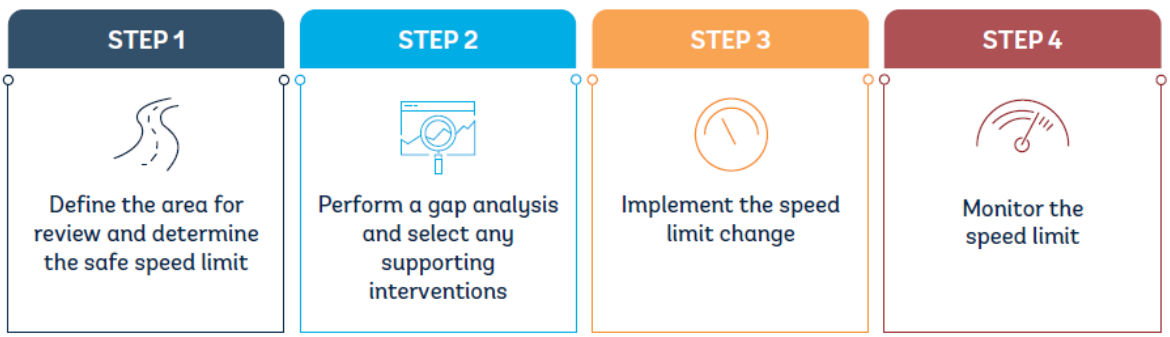
A speed management action plan should be prepared for implementing a speed management strategy. An action plan can be created as part of a speed management strategy, or separately, and it can be helpful in selecting and implementing interventions and monitoring and evaluating planned activities. When an action plan is created separate from a strategy, it is important to make it consistent with country policies and legal frameworks and to align it with any emerging national or local strategy.



Implementing safe speed limits based on the Roads-for-Life framework

Whether speed limits are being changed at specific locations, or as part of a broader process to improve a road corridor, whole city, or region, the same 4 basic steps are required:

1. Define the area for review and determine the safe speed limits using the Roads-for-Life framework. This is done by understanding the area's characteristics combined with local knowledge on risks, to assign the appropriate speed limit.
2. Compare this newly assigned speed limit to the existing one to identify supporting measures needed to assure compliance with the speed limit change.
3. Implement the new speed limit. This includes meeting legal obligations, updating speed limit registers, informing the public, providing supporting activity if required, and installing signs and related road or enforcement infrastructure.
4. Monitor the new speed limit and assess the impact of the new speed limit on road safety.

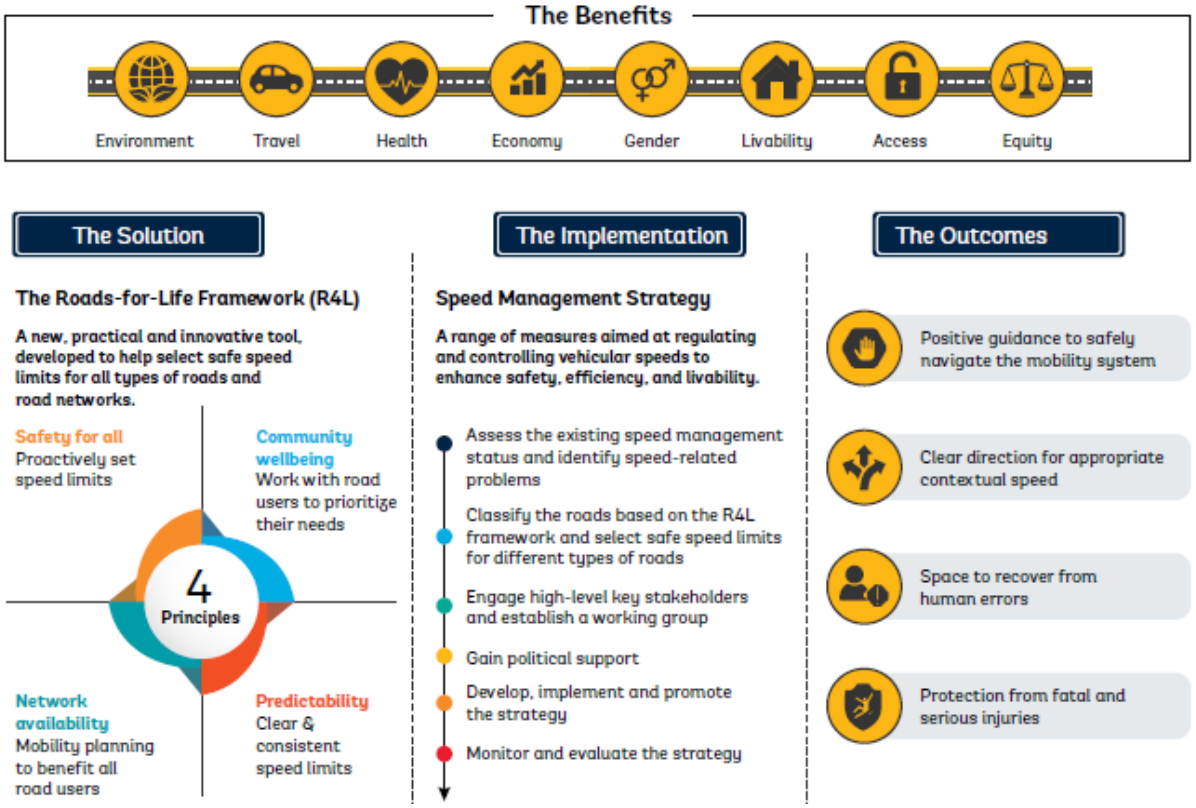


This 4-step approach adapts a best practice framework to various local needs. It allows countries or cities to improve different parts of their system as their resources allow and provides basic guidance for each stage, regardless of how robust existing systems are. It is possible to improve these systems as resources and expertise allow.

Source: Guide for Safer Streets, WRI India and World Bank Group

1. PROJECT PLANNING

Roads need to provide mobility and safety for vulnerable road users as well as moving other traffic and finding the right balance between competing demands is important. The image below presents a roadmap to designing and implementing speed management strategies to make the city's roads safe for all road users.



Source: Guide for Safer Streets, WRI India and World Bank Group

25 Kmph - School Zone Speed Management in Bengaluru by BTP
Location: 15th Main Road, Jayanagar, Bengaluru

Safe Routes to School (SRTS)

by Bengaluru Traffic Police (BTP)

As part of the Safe Routes to School (SRTS) project, the Bengaluru Traffic Police has installed new signage and road marker posts with reflectors around **six major school zones in the city**.

The fluorescent green signage indicate pedestrian crossings and speed limits. They also specify where the restriction ends. **The six zones cover 35 school.**

The demarcation highlights the School zone with Speed limit indication of 25 kmph for the demarcated stretch. These follow the new IRC SP:32

Source: Joint Commissioner of Police, Bengaluru Traffic Police


SANKEY ROAD
MILLERS ROAD
QUEEN'S ROAD
ALI ASKER ROAD
CUNNINGHAM ROAD
EDWARD ROAD
CHICK BAZAAR ROAD
PARK ROAD
VENKATASWAMY NAIDU ROAD
RACE COURSE ROAD
PALACE ROAD
RAJ BHAVAN ROAD
MUSICAL FOUNTAIN ROAD
INFANTRY ROAD
BOWRING HOSPITAL
PALACE ROAD PALACE ROAD
DEVARAJ URS ROAD
QUEEN'S ROAD
CUNNINGHAM ROAD
RAJ BHAVAN ROAD
INFANTRY RO
CUBBON ROAD
QUEEN'S ROAD QUEEN'S ROAD
LINK ROAD
SHESHADRI ROAD
DOCTOR B R AMBEDKAR VEEDHI
KING'S ROAD
SAINT MARK'S ROAD
NRUPATUNGA ROAD
LAVELLE ROAD
VITTAL MALLYA ROAD
KASTURBA ROAD
KEMPEGOWDA ROAD
KASTURBA ROAD
VITTAL MALLYA ROAD
SAINT MARK'S ROAD
RAJARAM MOHAN ROY ROAD
LAVELLE ROAD
RESIDENCY ROAD
HAYES ROAD
DEVANGA HOSTEL ROAD
JC ROAD
7TH MAIN ROAD
MISSION ROAD
SRI RAM MANDIR ROAD
RICHMOND ROAD
SJP ROAD JC ROAD
MISSION ROAD

02 DESIGN

2. DESIGN

1. INTRODUCTION

Designing, Engineering, and Implementation of Surface Level and Sub-surface Level Components of Roads

What is comprehensive development?

Comprehensive road development refers to a holistic approach to improving road infrastructure, not only encompassing resurfacing roads but also ensuring other upgrades that consider factors such as road safety, environmental impact, maintenance strategies, and utilizing advanced technologies to ensure efficient mobility, quality, and longevity of road infrastructure across the city. It often involves coordinated efforts between several government agencies and other stakeholders in the city.

Harekrishna Junction, Racecourse Road, Bengaluru. *Image: WRI India*

Why is comprehensive road development important?

Comprehensive road development is vital for creating sustainable, durable, and user-friendly road infrastructure. It ensures the longevity of roads by focusing on holistic planning and deploying engineering solutions that minimize frequent repairs. Additionally, it prevents unnecessary cutting of roads by streamlining and shifting utilities during the development process, thus saving costs and reducing disruptions to traffic and daily life.

Effective adherence to the process and its implementation addresses waterlogging concerns on the roads by integrating efficient stormwater drainage systems. This ensures pothole-free roads and safer conditions on roads. Furthermore, it caters to the needs of all road users, including pedestrians and vulnerable user groups, by incorporating safe and continuous footpaths, cycling lanes, and safe crossings. This inclusive approach promotes equitable access as well as enhances overall mobility, safety, and convenience for all users.

2. DESIGN

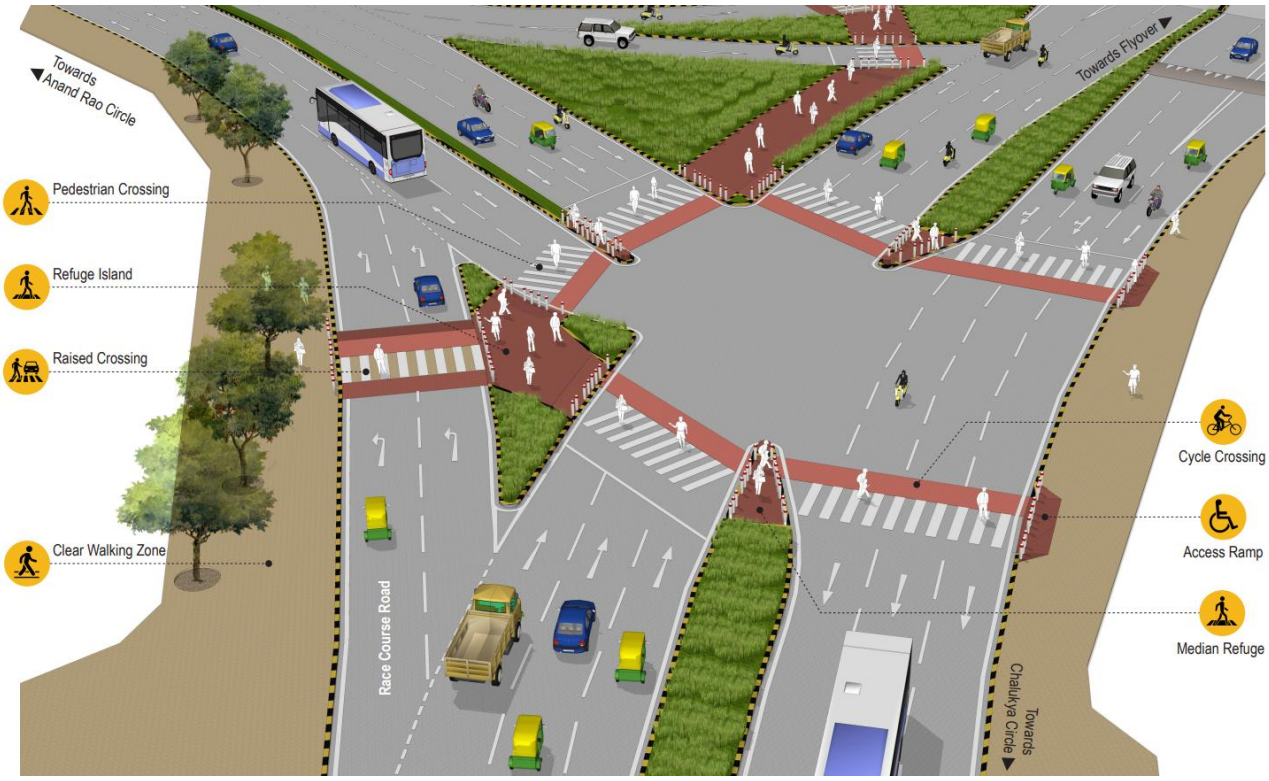
Comprehensive development:

- Enhances safety, mobility, inclusivity and resilience, ensuring that urban spaces are secure and accessible.
- Creates thoughtfully designed street edges that are functional, aesthetically pleasing, and conducive to safe and efficient vehicular and pedestrian movement.
- Significantly improves the overall quality of life and livability by creating vibrant, sustainable, and quality public spaces.

How to achieve comprehensive development?

The following are the key activities involved in the comprehensive development of roads in Bengaluru.

Development of Surface-Level Components



Graphics: WRI India

Geometric Design

Development and construction of well-designed contiguous carriageways, medians, junctions, and pedestrian-friendly infrastructure are essential for creating safe and accessible urban spaces. This includes constructing and maintaining continuous obstruction-free footpaths that allow for unhindered pedestrian movement by incorporating safe crossings, refuge areas, and other road infrastructure that ensures safety of both vehicle users and pedestrians at midblock and junctions.

Shaded and well-lit footpaths with greenery provide comfort and encourage walking, while accessibility features such as ramps and tactile paving ensure inclusivity for children, older people and and people with disabilities. Additionally, providing wayfinding signages and completing necessary paint marking on roads directs vehicles and pedestrians in the desired direction, thereby avoiding conflicts leading to crashes.

Geometric design involves the following major components

1. Design and development of midblock and junctions, including contiguous lanes, medians, painted crossings, speed calming measures etc. wherever necessary
2. Design and development of continuous footpaths
3. Landscaping of footpaths and junctions, wherever necessary
4. Provision of street furniture and amenities including bus shelters, signages, benches etc.
5. Provision of streetlights

Pavement Design

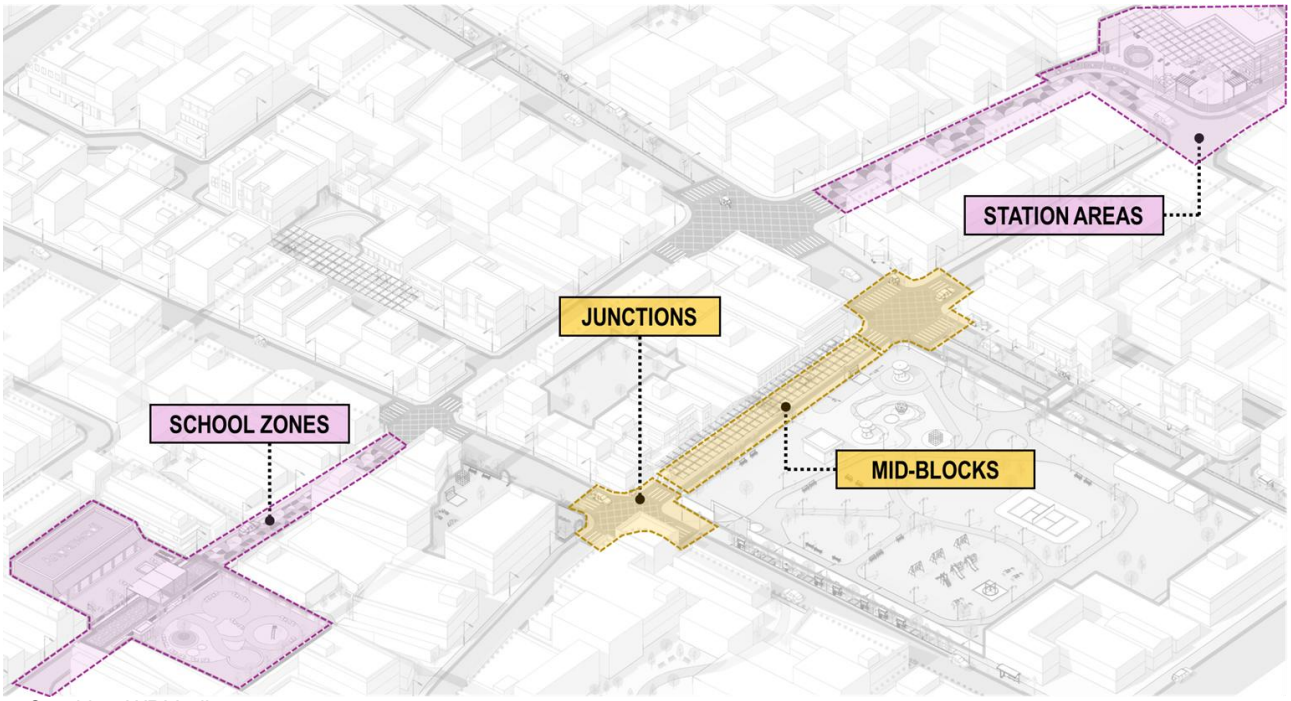
Pavement design includes developing and strengthening of carriageways by **asphalting or white topping** roads. It plays a crucial role in ensuring the durability and safety of road infrastructure. It involves strategic planning and layering of materials to create a strong and long-lasting surface capable of withstanding varying traffic loads and environmental conditions. While asphalting is a commonly used method, white-topping ensures enhanced durability and resistance to wear and tear. White-topping is particularly effective in areas with heavy traffic or extreme weather, as it reduces maintenance requirements and provides a longer lifespan.

Sub - Surface level

Roadside Stormwater Drains with required shoulders - The design and implementation of sufficient stormwater drains are critical for increasing the lifespan of roads. Proper drainage systems prevent waterlogging, which is a major cause of road damage, such as potholes and erosion. By efficiently channeling rainwater away from the road surface, stormwater drains reduce water infiltration into the pavement layers, minimizing structural weakening and extending the durability of the roads. Additionally, they help maintain smoother surfaces and lower long-term maintenance costs, ensuring safer and more reliable infrastructure.

Construction of utility ducts and shifting of **Utilities** wherever essential **-** Upgrading utilities while relaying roads not only reduces costs but also prevents frequent road cutting and helps maintain road quality. Restoring old utilities and shifting overhead cables underground enhances safety, reduces visual clutter, and minimizes weather-related damage. Adopting newer technology and replacing large transformers with smaller modern ones helps improve energy efficiency and space utilization. These upgrades ensure long-term reliability and lower maintenance costs.

2. DESIGN
OF ROADS AND SPECIAL AREAS



Graphics: WRI India

ROADS

JUNCTIONS

Types of junctions, components of a junction, design elements to make junctions safer for pedestrians

MID-BLOCKS

Types and components of corridors, design of public spaces, blue-green infrastructure and appropriate materials

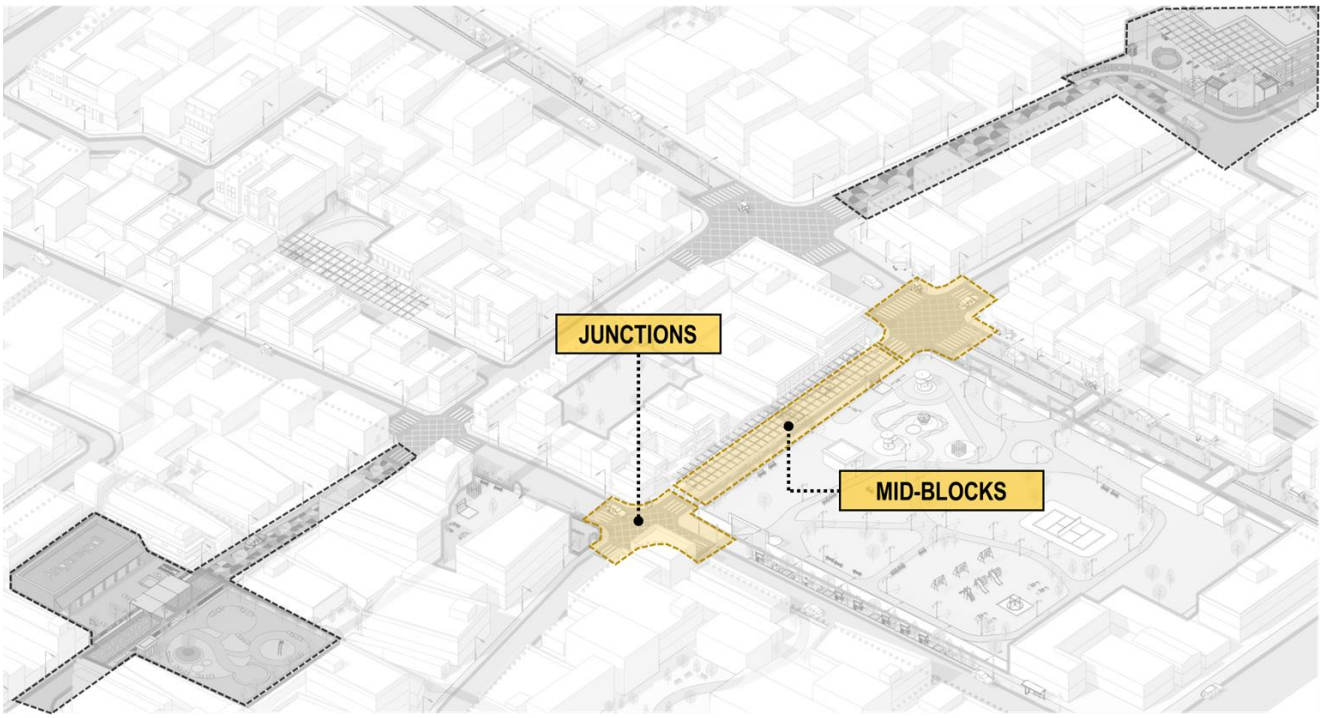
SPECIAL AREAS

SCHOOL ZONES

Design for drop-off zones, Placemaking guides including play elements and street furniture for children safety

STATION AREAS

Design for better last-mile, bus stops, IPT, on-street parking and Multi-Utility Zones including vending zones



Graphics: WRI India

1 | ROADS

WARD ROADS

Road design includes the planning and designing of both midblocks and junctions, ensuring efficient traffic flow and safety of all road users.

Midblocks (corridors) are the sections between junctions, where factors like lane widths, lane contiguity, footpaths, and pedestrian crossings are to be designed and implemented. Junctions, on the other hand, involve the designing of intersections, incorporating speed calming measures, traffic signals, turn lanes with ideal turning radii, etc. to manage vehicle movements effectively.

Designing of both components is essential for creating a well-functioning road network in the city.

1.1 MIDBLOCKS (CORRIDORS)

Designing streets of all Right of Way (ROWs) is essential for creating safe, inclusive, and resilient urban environments. Well-planned streets accommodate all kinds of road users including pedestrians, cyclists, motorists, and public transport users, ensuring accessibility and mobility for everyone. Well-designed streets contribute to a more sustainable and livable city by taking into consideration factors such as land use, traffic flow and volume, pedestrian volume, universal accessibility.

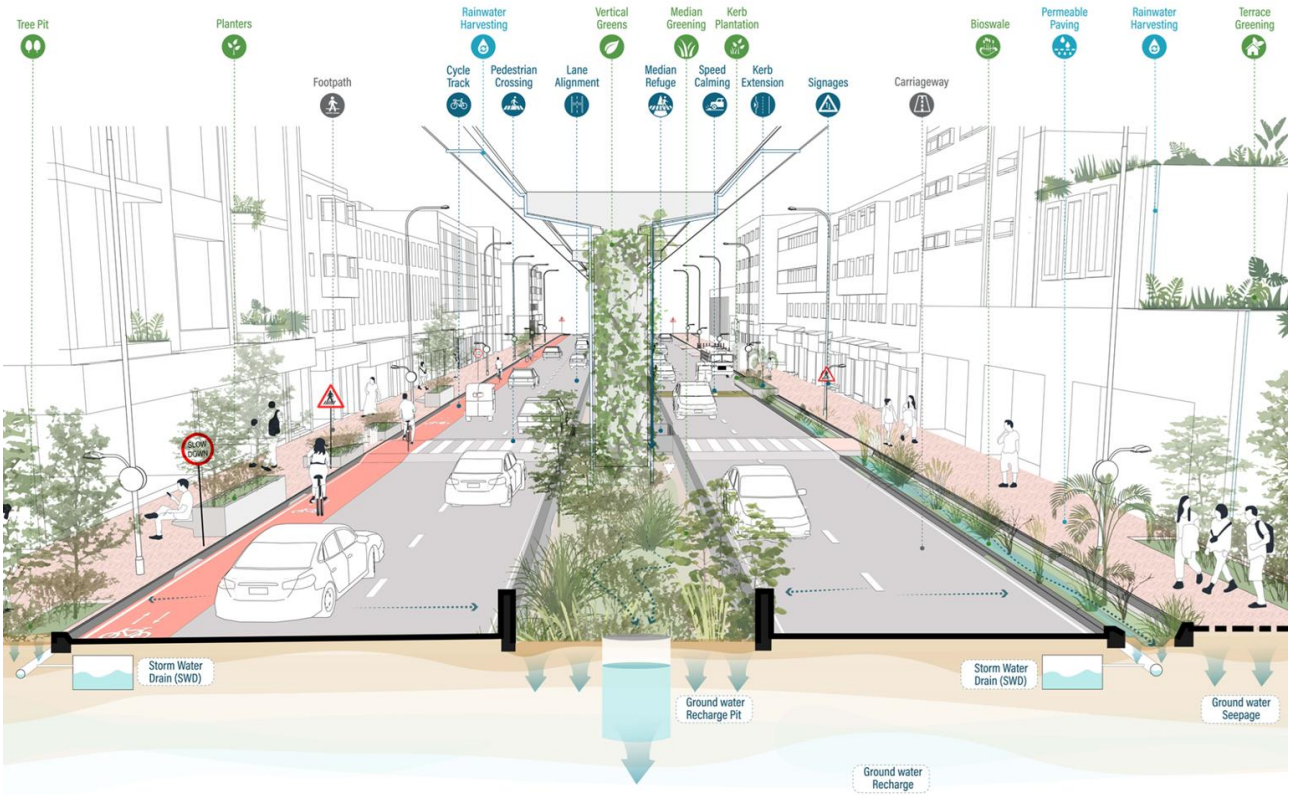
Image: High Density Corridor Design Standards Manual, Maya PRAXIS

Standards such as IRC provide guidelines for proper lane widths, pedestrian crossings, signage, and other critical elements to reduce the risk of crashes and improve traffic flow. It is therefore important to follow these standards and adapt to local conditions to support the mobility and well-being of all road users.

1.1.1 Typical Midblock Components

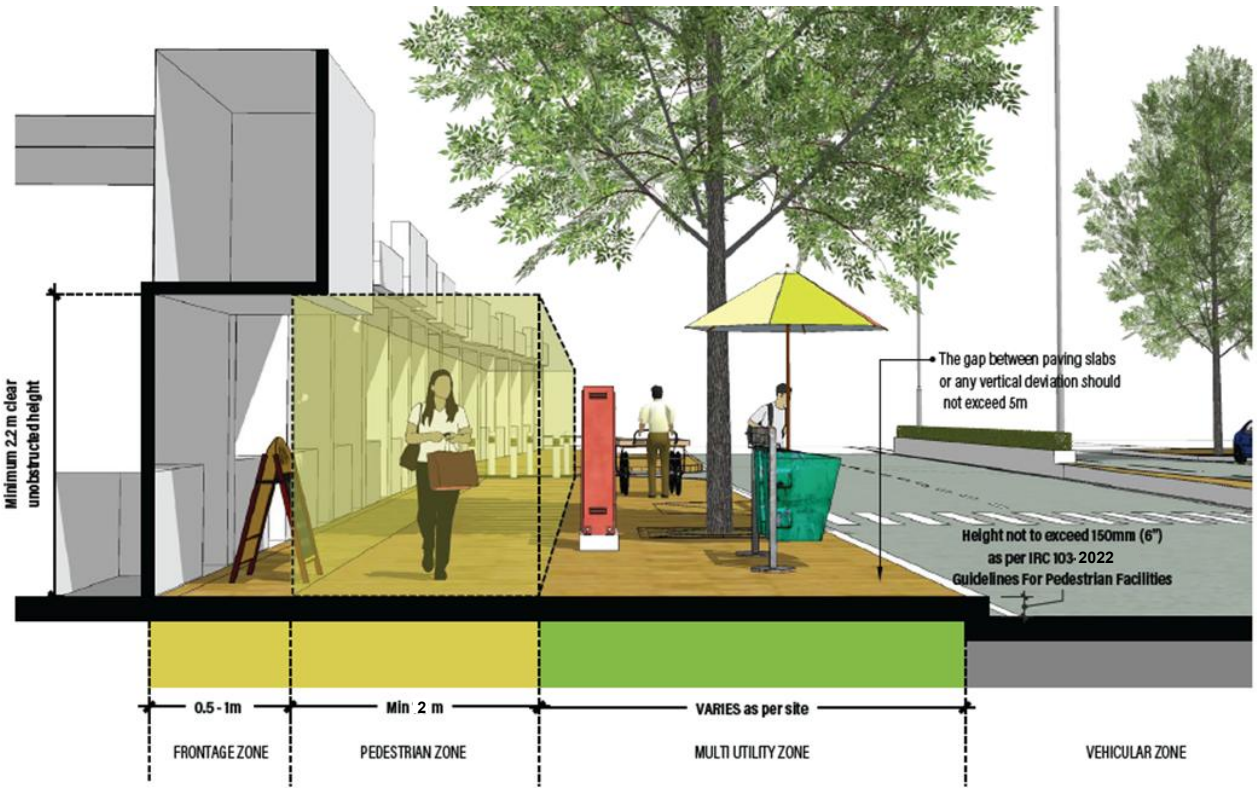
A typical midblock consists of the following key components. Adhering to design standards and tailoring these elements to site-specific conditions will contribute to safer, more inclusive, and resilient streets for all road users.

- Comfortable footpaths for pedestrians with a minimum width of 2000 mm (IRC:103 - 2022)
- Cycle tracks with a minimum width of 1,500 mm.
- Level crossings at footpath level at all property entrances and junctions
- Access ramps to private properties
- Bollards, green buffers and other barriers to restrict and regulate vehicular entry
- Landscaping such as trees and green strips
- Street furniture such as benches, recycling and waste receptacles
- Street lighting consisting of low-level lighting for pedestrian areas and high masts or appropriate lighting for the carriageways
- Signage such as direction signs, location signs showing street names and numbering, information signs including restrictions, warnings and updates.



Graphics: Yash Siroliya/WRI India

1.1.2 Footpath Design Elements



Graphics: Shubhra Kansal and Akhila Suri/ WRI India

1.1.2.1 Clear Walking Zone

Also known as the pedestrian zone, this is a space required for 4 persons or 1 wheelchair + 2 persons to traverse comfortably. This provides pedestrians a clear unobstructed walking zone to use.

IRC: 103 - 2022

This zone should be at least 2m wide and have a vertical clearance of 2.2m (as per IRC: 103 - 2022 'Guidelines for Pedestrian Facilities'). This zone should be free from any obstructions such as planters, utility boxes, electric poles or spillover from shops etc. This zone is critical in ensuring the usability of any footpath. Additional space on footpath shall be provided for other aforementioned purposed, which might lead to a minimum width of the footpath to be approx. 4.5m to 7m based on the need of the junction.

1.1.2.2 Kerb Height Specifications

It is the height of the kerb stone from the finished road surface.

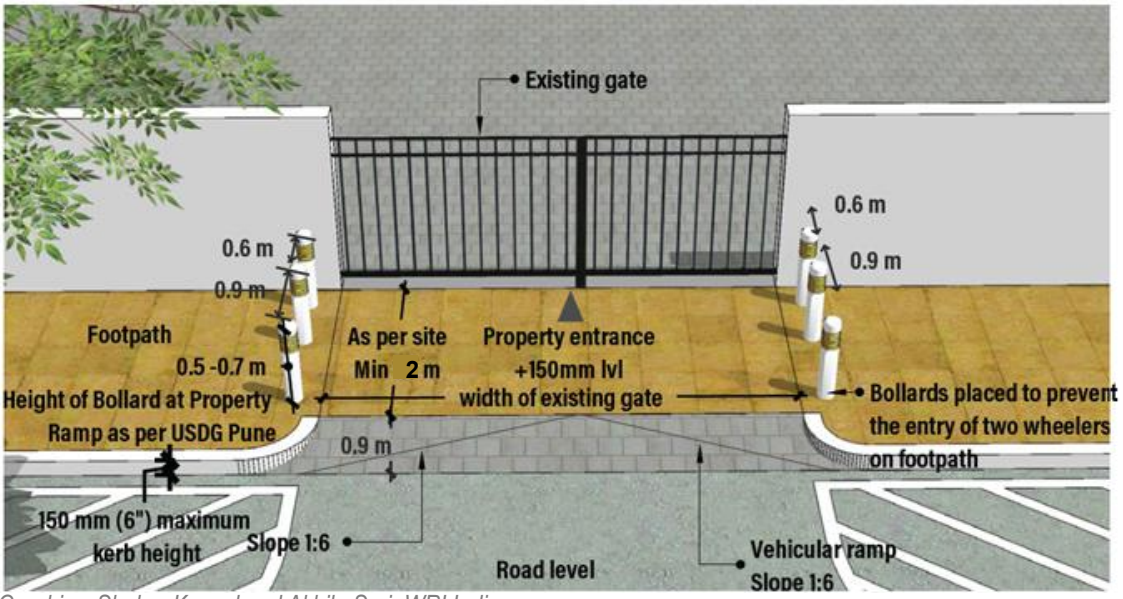
IRC: 103 - 2022

The height of the footpath at any given point shall not exceed 150mm (6") from the top of the road as per IRC: 103 - 2022, 'Guidelines For Pedestrian Facilities'

1.1.2.3 Property Ramps

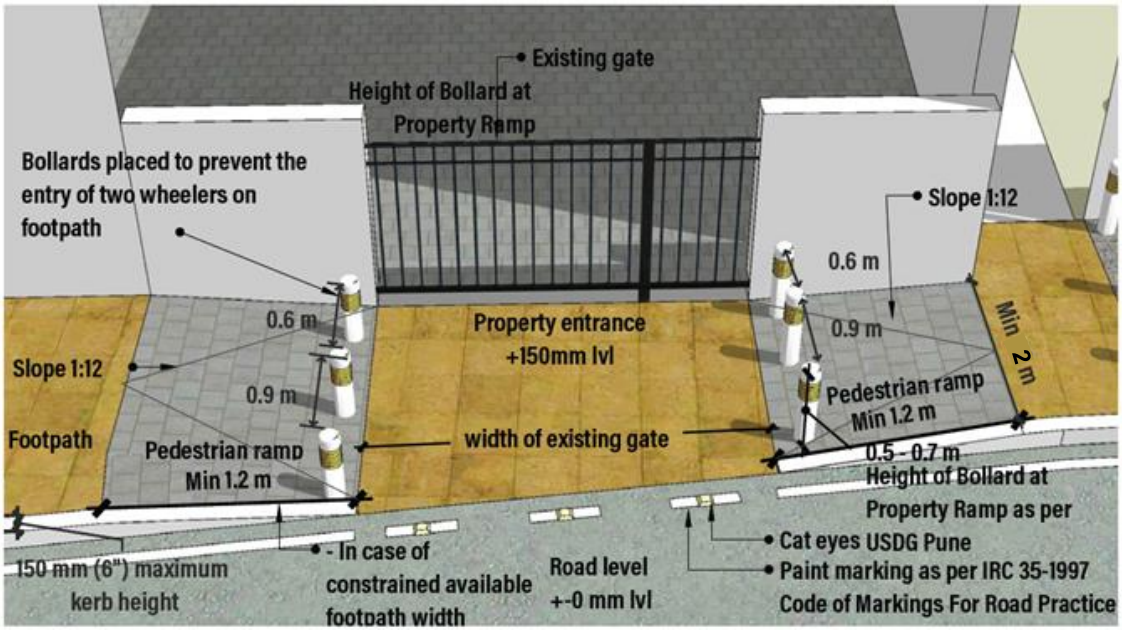
Property ramps are provided to allow vehicular access to properties near the intersection. Cuts in the footpath to allow vehicular access should be avoided as it hinders pedestrian movement.

IRC:35 - 2015 'Code of Practice for Road Markings', WRI India



Graphics: Shubra Kansal and Akhila Suri, WRI India

Type 1 - Vehicle Ramps (Preferred): Gradient for vehicle ramps should be 1:6 (i.e. 0.9 m wide vehicular ramps for a kerb hieght of 150 mm). If the footpath width is >3.5 m, vehicular ramps are recommended to be provided on either side of the walking zone.



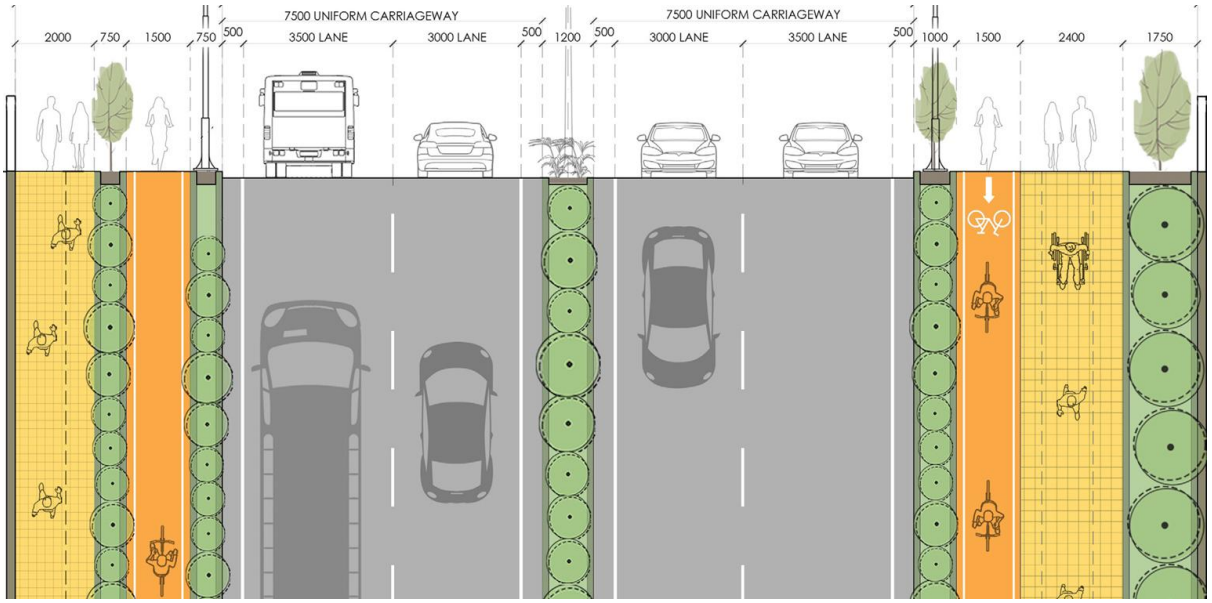
Graphics: Shubra Kansal and Akhila Suri, WRI India

Type 2 - Pedestrian Ramps (In Case of Narrow Footpath): Pedestrian ramps of a gradient not greater than 1:8 (i.e. 1.2 m long pedestrian ramps for a kerb height of 150 mm) are used to provide access for pedestrians and wheelchair users to the adjoining properties. Kerbs in front of the gate should protrude slightly by 15 mm to 25 mm from the top of the road level to prevent collection of rainwater.

1.1.3 Carriageway Design

1.1.3.1 4-Lane Road

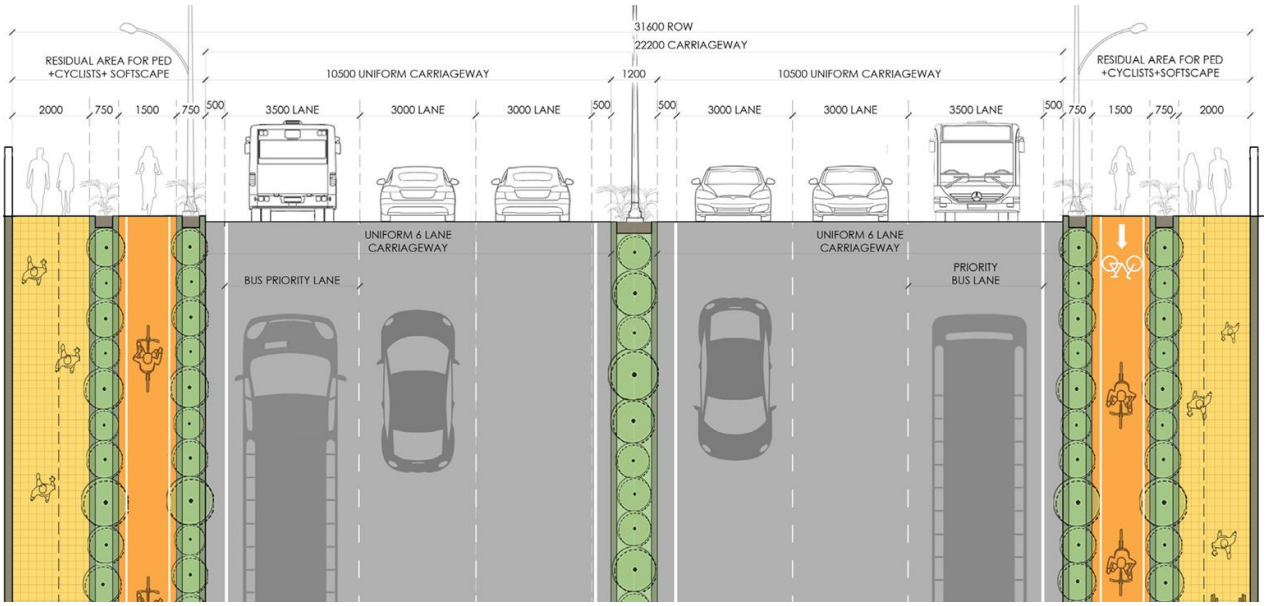
Based on IRC 86-2018, two-way vehicular carriageway in a four lane road is suggested to have two carriageways of width 7.5m with a separating median. The outer lane if of width 3.5m to accommodate larger vehicles such as buses, while the inner lane is 3m wide. A shy-away zone on either side of each carriageway of 0.5m is suggested.



Graphics: High Density Corridor Design Standards Manual, Maya PRAXIS

1.1.3.2 6-Lane Road

Based on IRC 86-2018, vehicular carriageway in a six lane road shall have an average width is 10.5m each separated by a median. Two lanes have a uniform width of 3m. The peripheral/ left most lane is to be treated as a bus lane, and shall have a consistent width of 3.5m. Shyness along both sides of carriageway shall be 0.5m.

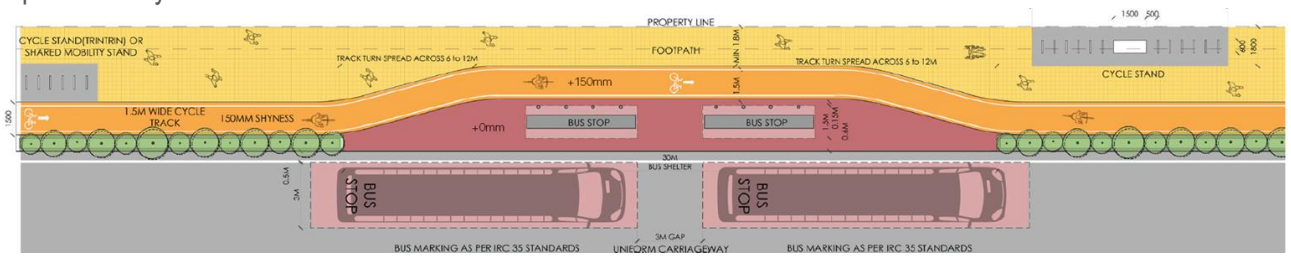


Graphic: High Density Corridor Design Standards Manual, Maya PRAXIS

Carriageway should be uniform in a particular section. However, where changes are unavoidable, a transition of 1:20 must be provided.

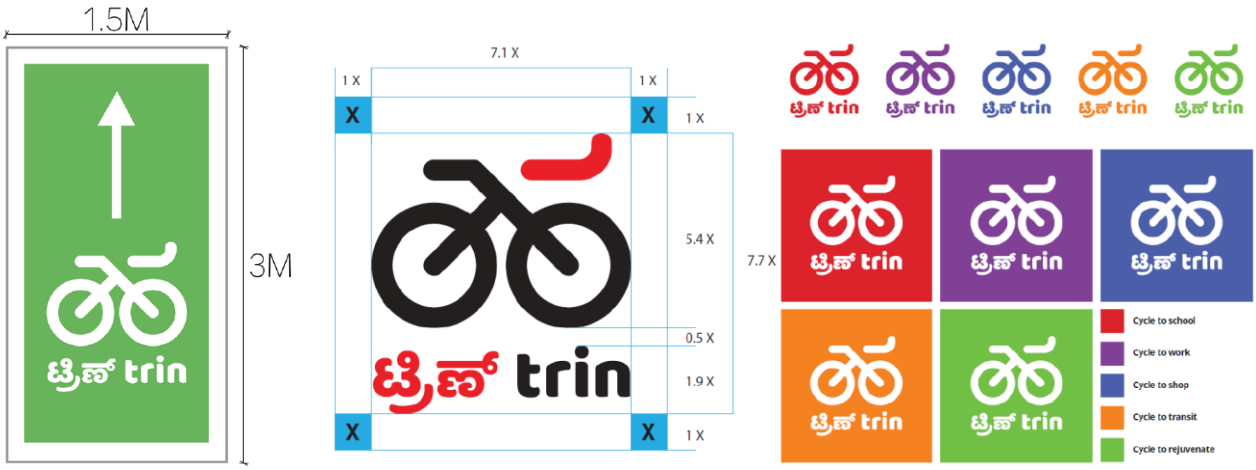
1.1.3.3 Cycle Tracks

A unidirectional cycle track of 1.5 m width shall run largely along the kerb landscape at a level of +0.15m from the road, unless local conditions dictate otherwise. The cycle track re-routes behind the bus shelter.
In case of excess width (4.5m to 6m) on pedestrian footpaths, a bi-directional cycle track of 3 m width (1.5m + 1.5m) shall run along the median landscape at +/-0.00m level on the carriageway and shall be protected by bollards.



Graphics: High Density Corridor Design Standards Manual, Maya PRAXIS

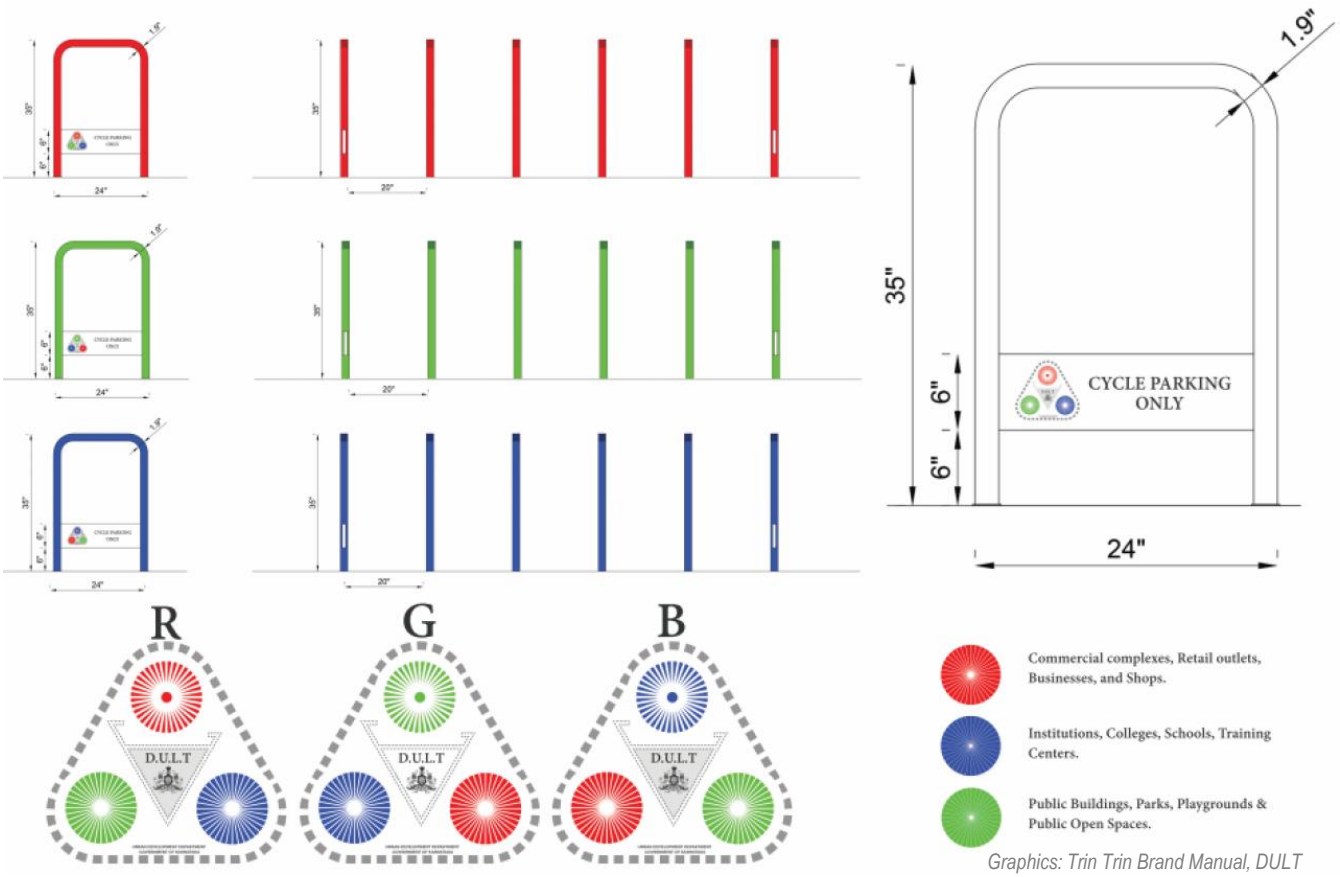
Trin-Trin Signage: As per Directorate of Urban Land Transport (DULT) TrinTrin Brand Manual, the cycle symbol is to be stamped in white within a green box and shall be located at the beginning and end of each stretch of the cycle track. The green box shall be 3 m long and 1.5 m wide and shall have a white border as indicated in the diagram. After every 100 m of the continuous cycle track, an additional stamp shall be introduced. Cycle tracks running along a bus stop shall be stamped at mid-length as indicated. The cycle lane is to be marked by a continuous green line all along its length on both sides.



Graphic: Trin Trin Brand Manual, DULT

1.1.3.4 Cycle Parking

The following are the specifications for cycle parking stands as per the DULT design and standards.



Graphics: Trin Trin Brand Manual, DULT

Bicycle parking at Jayanagar Metro Station, Bengaluru. *Source: WRI India*

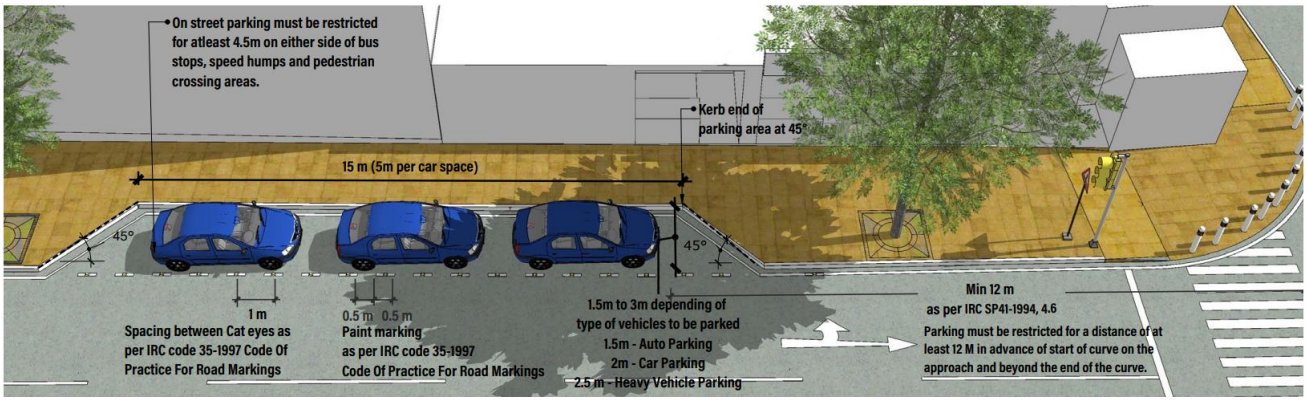
1.1.3.5 On-Street Parking

It allows for vehicles to be parked on the street, anywhere on or along the kerb of streets.
IRC 103-2022, IRC 86-2018

On-street parking must be restricted to a distance of at least 4.5 m on either side of bus stops, speed humps, and pedestrian crossing areas. Pay and park may be recommended in areas where the space and demand are available. On-street parking, where provided, must be restricted for a distance of at least 12 m in advance and beyond the intersection approach roads. On-street parking specifications are listed below:

- Minimum of 1.8 m for two-wheeler, auto-rickshaw, cycle rickshaw and taxi/car parking. There shall be no segregation or demarcation of separate two - wheeler and four - wheeler parking.
- 22.5 m to 3.0 m for heavy vehicle parking.

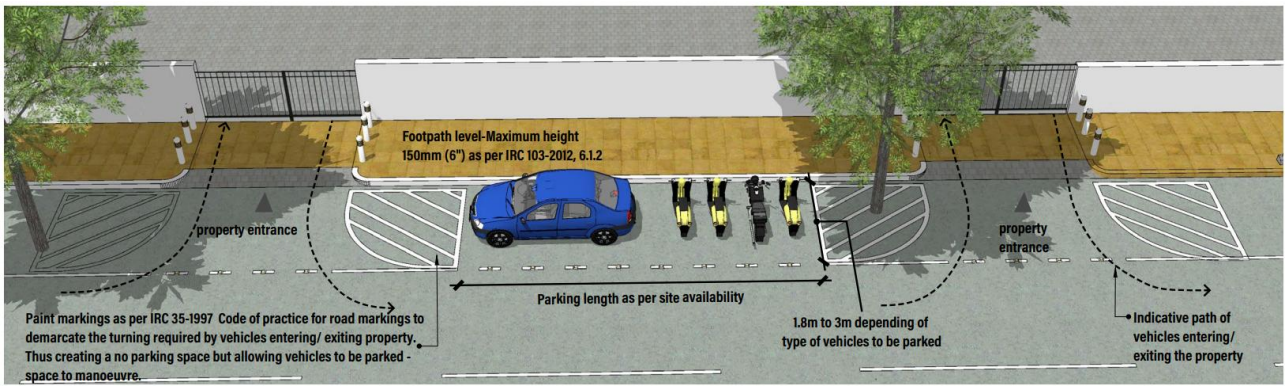
There are two scenarios in which on-street parking is provided.



Graphics: Shubhra Kansal and Akhila Suri/ WRI India

Type 1: Standard Inset in Footpath

In this scenario, a minimum 1.8 m deep inset is provided in the footpath as a parking bay. After estimating the parking requirements for different types of vehicles, the width of the parking bay can be reduced to regulate on-street parking. This will help in reclaiming excess parking space for wider footpaths. The parking bay must be demarcated with road markings as per IRC: 35-2015.

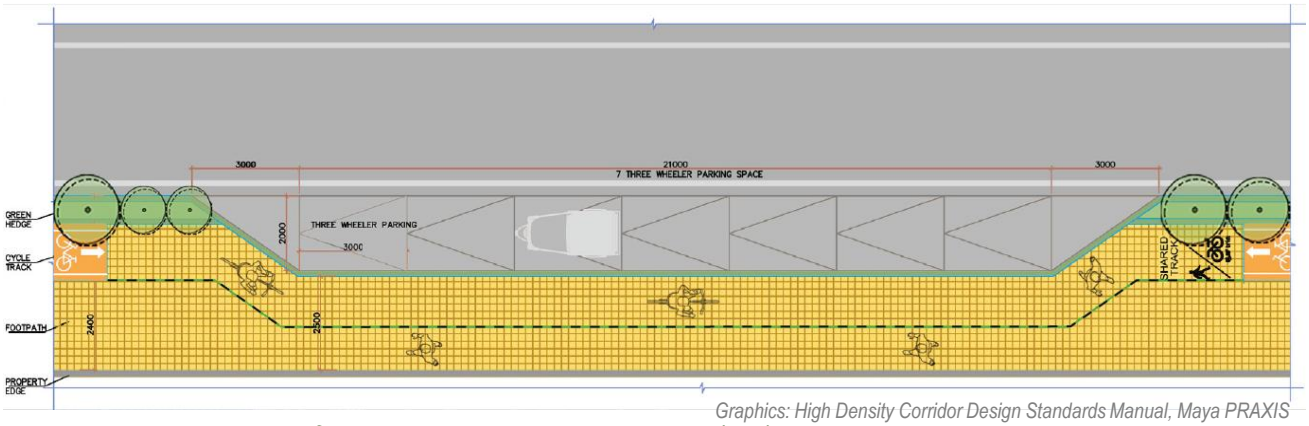


Graphics: Shubhra Kansal and Akhila Suri/ WRI India

Type 2: Road Marking Demarcation (In Case of Site Constraints)

In cases where property gates are closely spaced, the parking bay shall continue in front of the gates with appropriate road markings.

1.1.3.6 IPT Bays

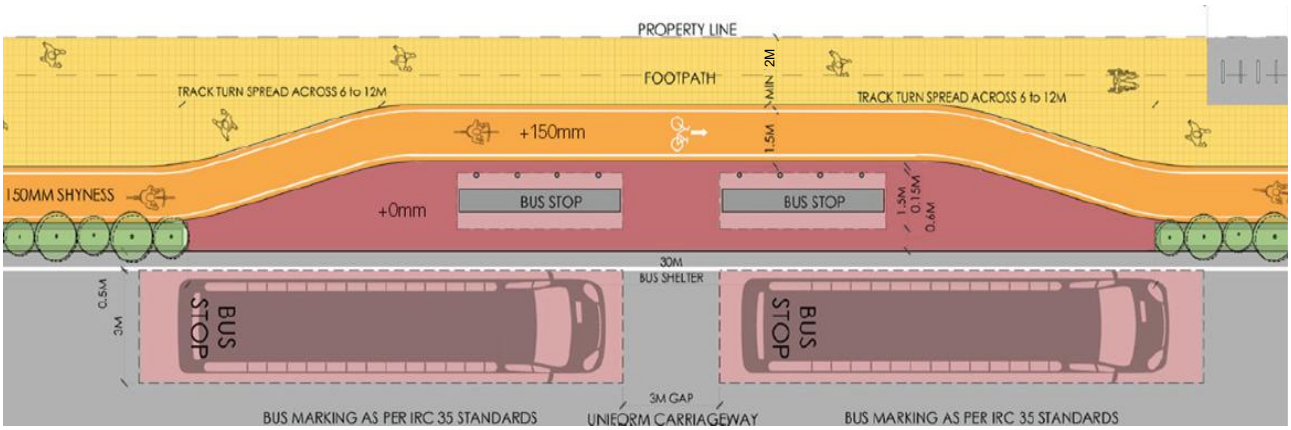


Graphics: High Density Corridor Design Standards Manual, Maya PRAXIS

It is the area designated for Intermediate Public Transport (IPT) services such as autos to park and also wait while passengers get on/off

The standard for parallel parking of autos is 3 m x 2 m while that for perpendicular parking its 3 m x 2.5 m.

1.1.3.7 Bus Stops

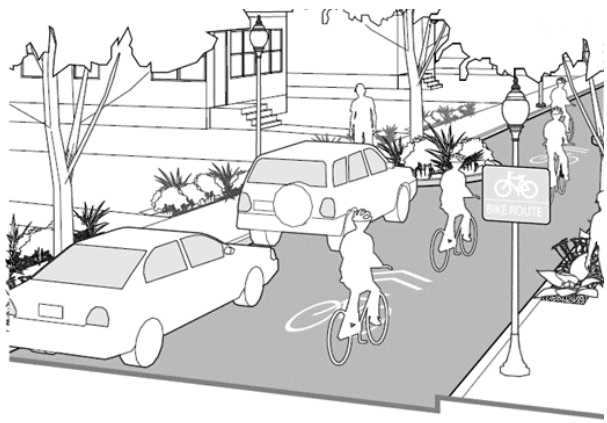


Graphic: High Density Corridor Design Standards Manual, Maya PRAXIS

It is the area designated for buses to wait while passengers get on/off the bus.

The bus stop should be located 75 m from the intersection preferably on the further side of the intersection. Relocation of existing bus stops could be recommended if it is considered unsafe.

1.1.3.8 Shared Streets



Graphics: Low Speed Zone Guide, WRI

- These are streets with lower motor vehicle speeds that allow bicycles to travel comfortably on the roadway in a low-stress environment.
- Bicycle boulevards use signs, pavement markings, and speed-calming measures throughout low-speed streets (30 km/h or less) to encourage lower motor vehicle speeds and allow for narrow travel lanes.

1.1.4 Median Design

1.1.4.1 At-Grade Typical Crossing

These are provided at unsignalized midblock locations.

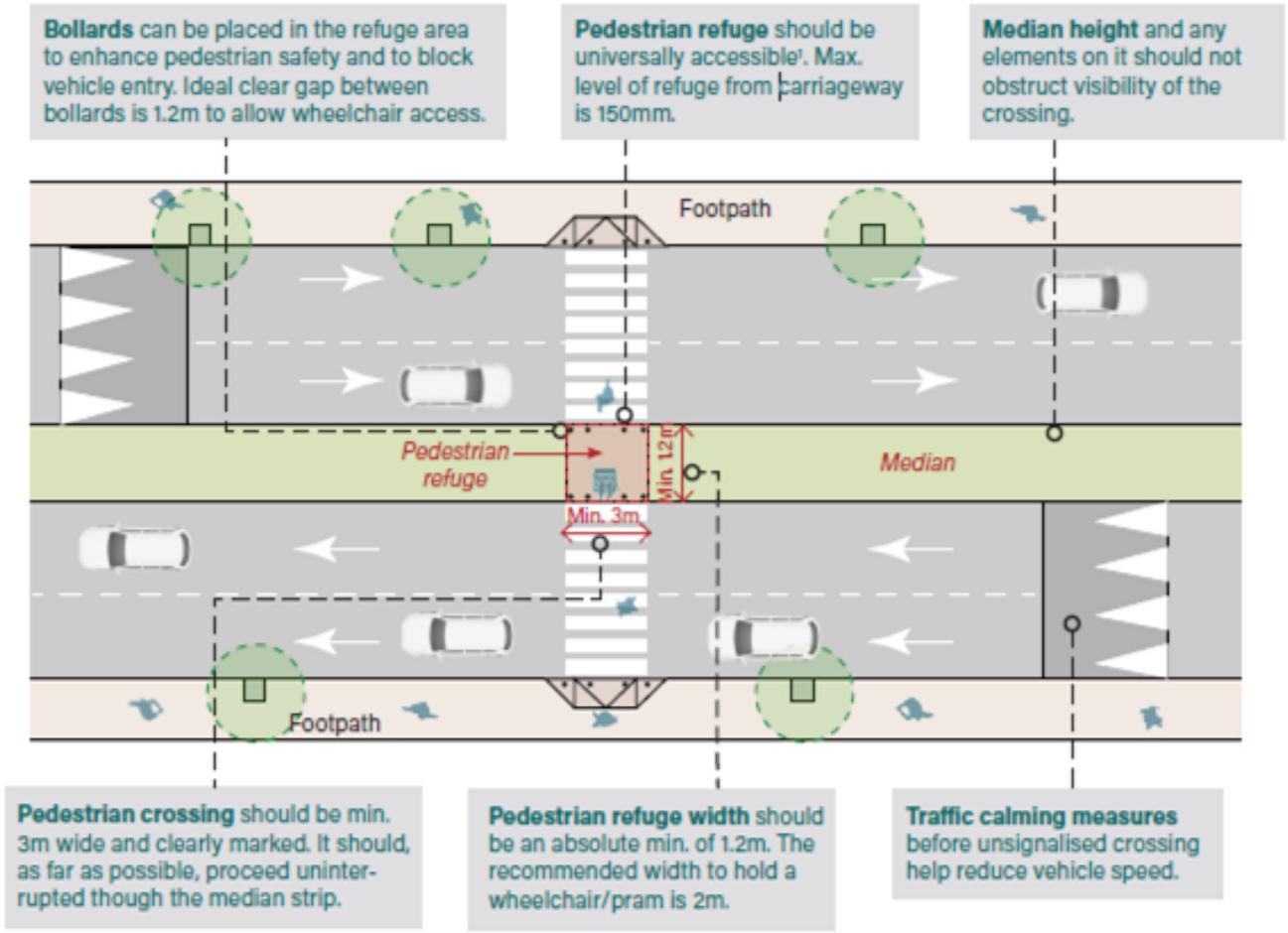


Image Source: WRI India, Recreated from Fig.3.12, IRC:99-2018

Pedestrian Crossing in Bhubaneshwar, Odisha. The low median height ensures good visibility, while the crossing being at a uniform level ensures universal accessibility. *Source: Telegraph India*

Crossing with median opening along Bellary Road, Bengaluru. Bollards prevent usage by vehicles while the wide and clearly marked crossing guides pedestrians across the road. *Source: WRI India*

1.1.4.2 At-Grade Crossing with U-turn

At signalized midblock crossings with a vehicular U-turn, the following template may be considered. This design allows vehicles to take U-turns in both directions and provides a safe crossing path for pedestrians.

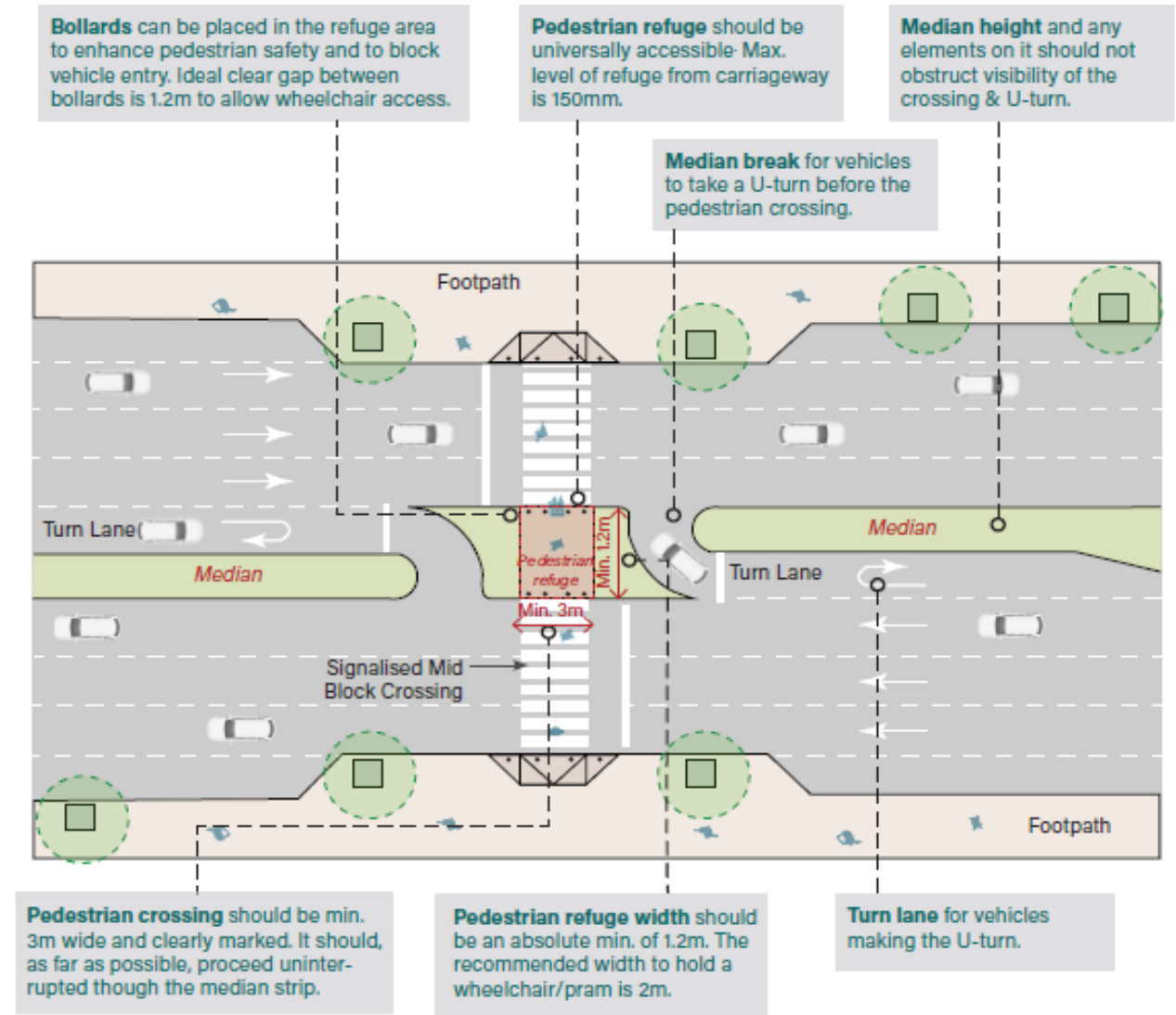


Image Source: WRI India, Recreated from Abu Dhabi Urban Street Design Manual

A crossing with median in Delhi has utility boxes flush with the paving, allowing for universal accessibility.
Source: Delhi PWD

Textured pavers help alert drivers of the upcoming rossing
Source: Delhi PWD

1.1.4.3 At-Grade Staggered Crossing

Staggered midblock crossings with a median refuge may be provided to allow pedestrians to look for gaps in the traffic in only one direction at a time, while facing the oncoming traffic. At unsignalized locations, traffic calming measures must be introduced before the crossing.

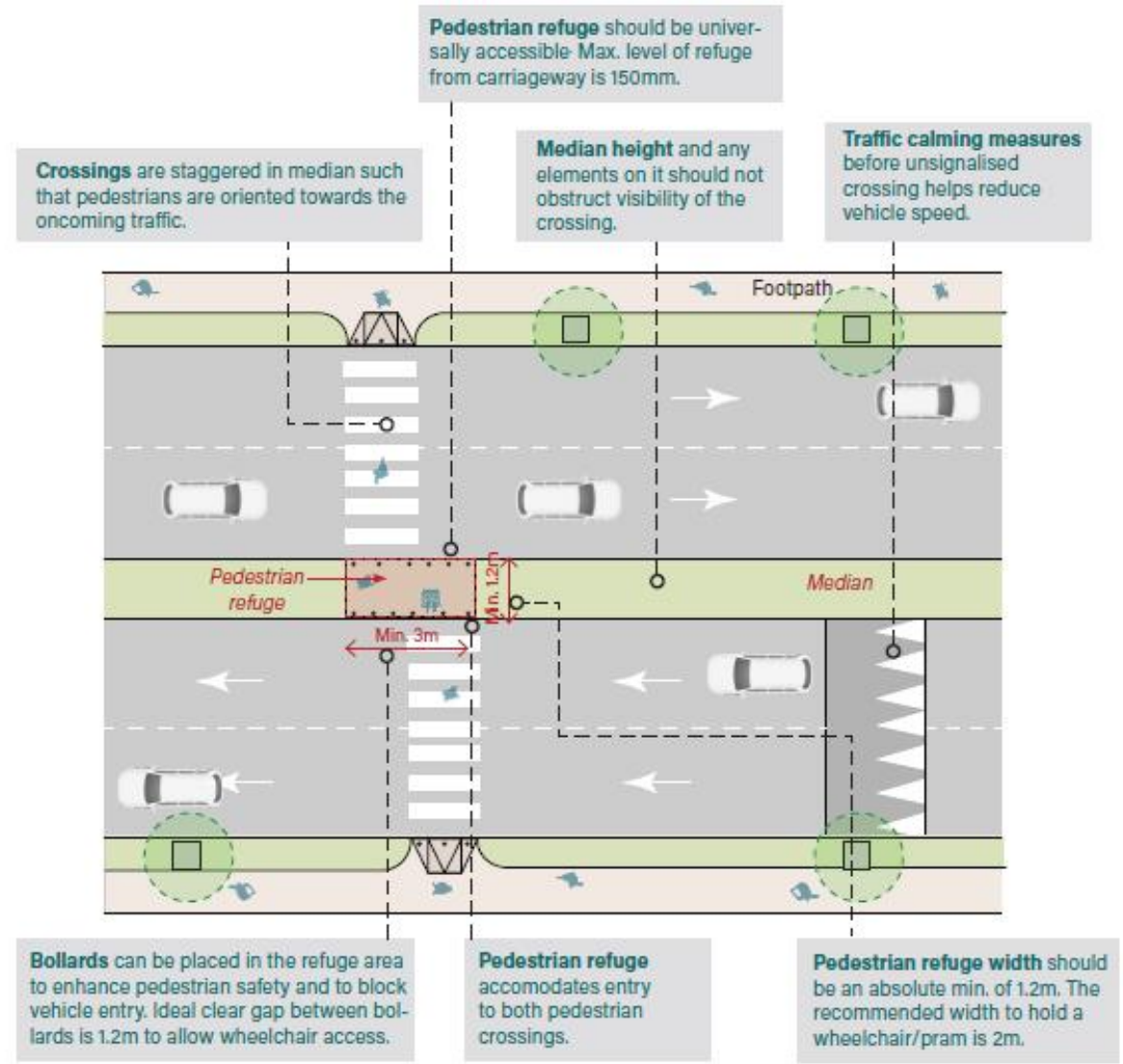
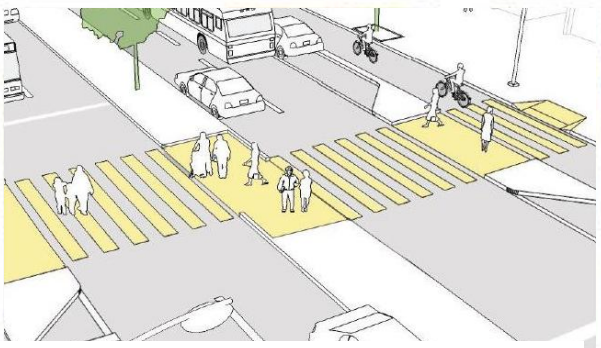
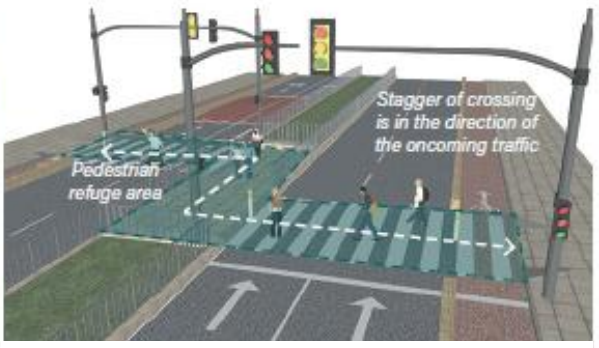


Image Source: WRI India, Recreated from Federal Highway Administration Research and Technology, USDOT



Staggered crossings allow for greater pedestrian waiting space at medians. *Source: GDCI*



Staggered crossings improve safety by making pedestrians face oncoming traffic. *Source: WRI India*

1.1.4.4 At-Grade Staggered Crossing with U-turn

At signalized locations, vehicular U-turns may also be integrated with staggered midblock crossings.

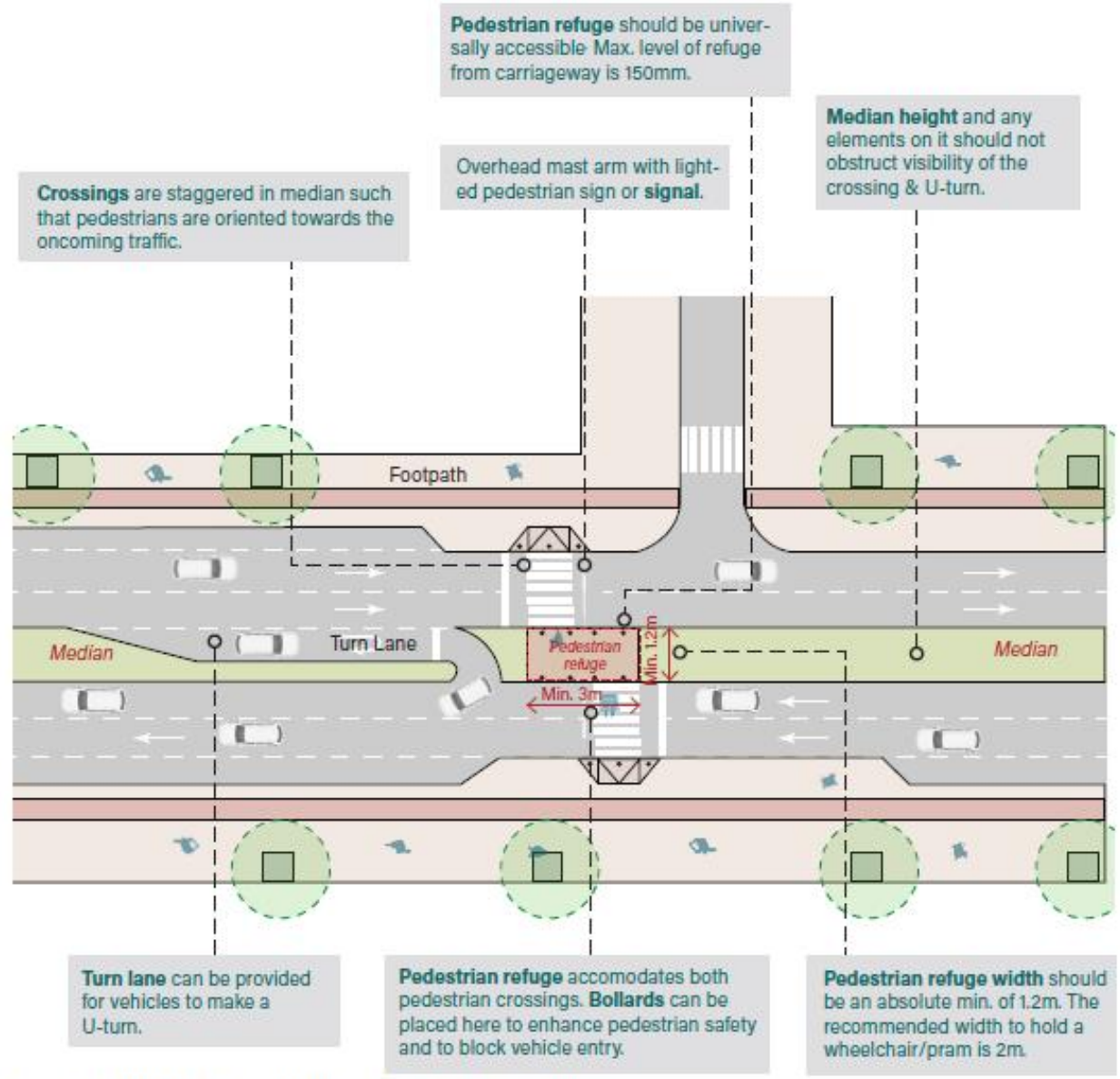


Image Source: WRI India, Recreated from Abu Dhabi Urban Street Design Manual

The median protects pedestrians from the U-turn movement.
Source: Spinkle Consulting

Crossing should be placed after the U-turn, to avoid conflict
Source: Pedbike Images

1.1.4.5 Raised Crossing

Midblock raised crossings enhance safety of pedestrians crossing to the opposite side at unsignalized locations. They compel drivers to travel at a lower speed before the crossing.

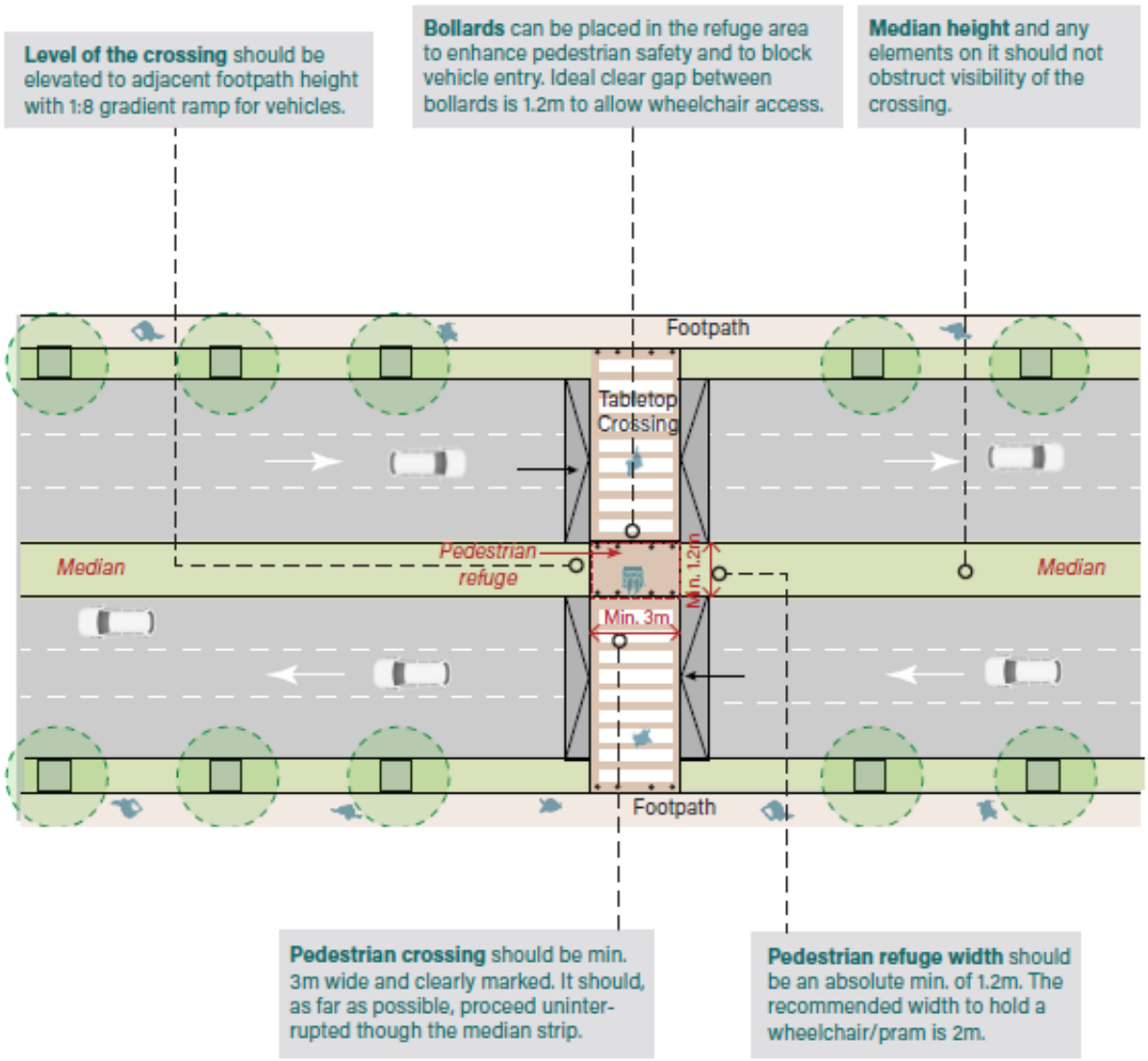


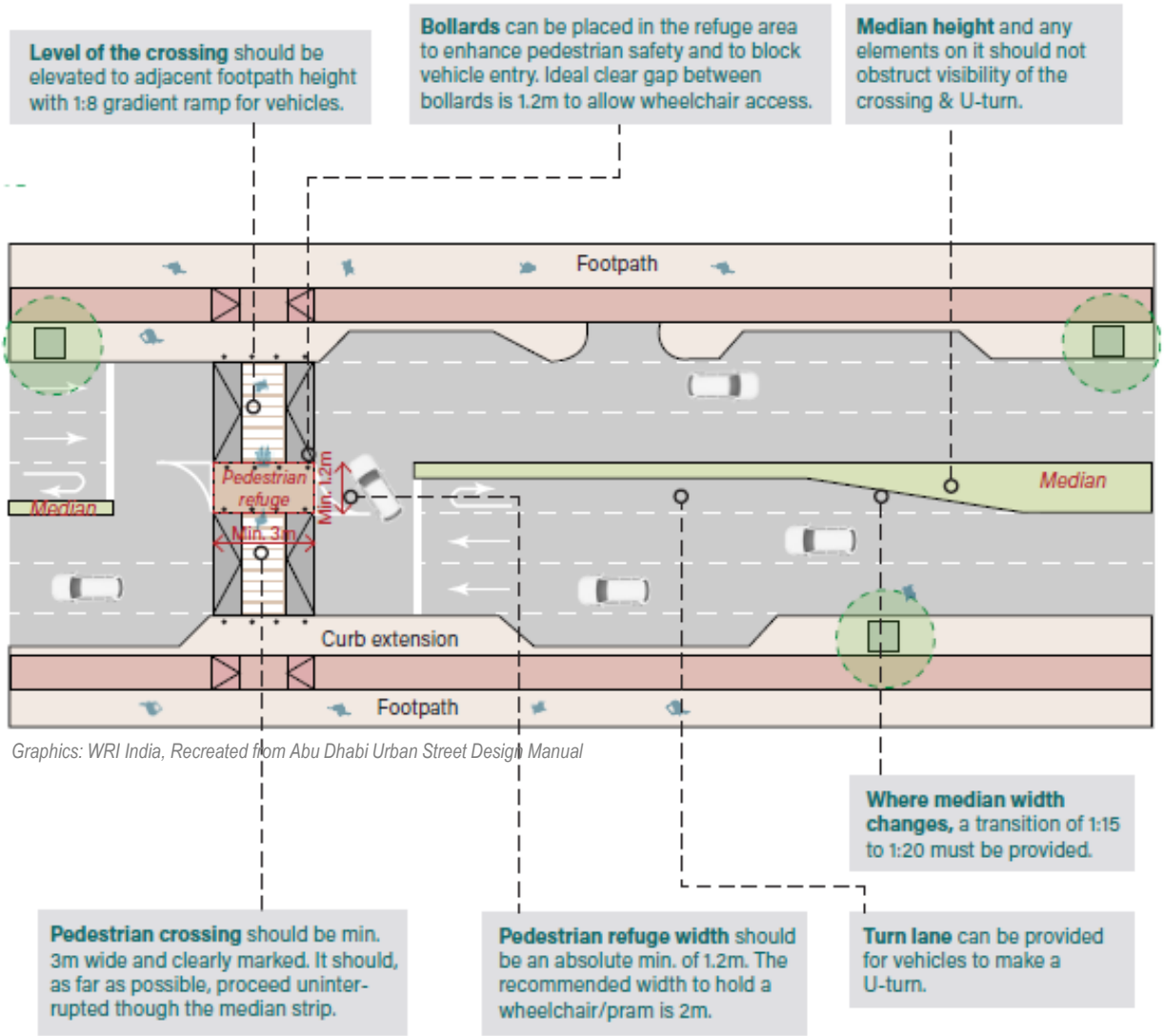
Image Source: WRI India, Recreated from IRC:103-2012

This mid-block HRPC on Kanakapura Road, Bengaluru offers pedestrians a seamless, uniformly-level crossing.
Source: WRI India

Textured pavers help those with visual impairments navigate this Delhi crossing.
Source: Delhi PWD

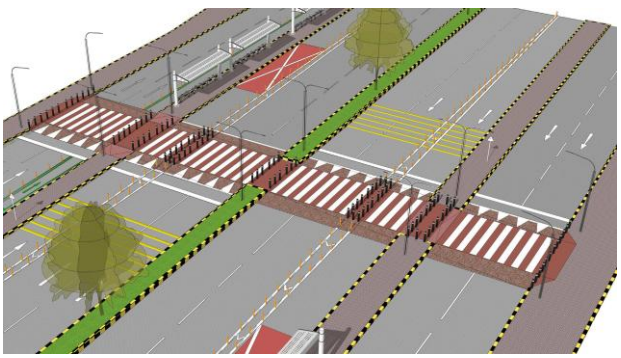
1.1.4.6 Raised Crossing with U-turn

At unsignalized locations, raised crossings may be provided for pedestrians to cross. The median can also be designed to accommodate vehicular U-turns.



Graphics: WRI India, Recreated from Abu Dhabi Urban Street Design Manual

This HRPC in Bengaluru slows drivers to improve pedestrian crossing safety
Source: ITDP



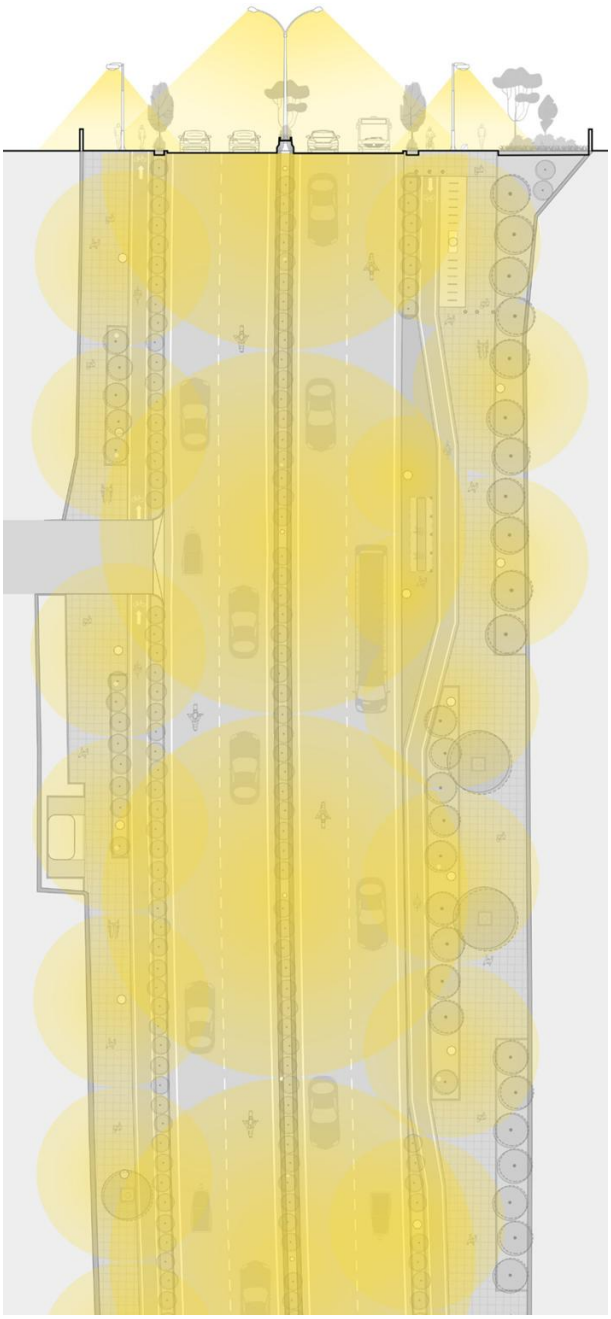
This mid-block HRPC along the Outer Ring Road, Bengaluru includes rumble strips to further reduce vehicle speeds
Source: WRI India

1.1.5 Place Making

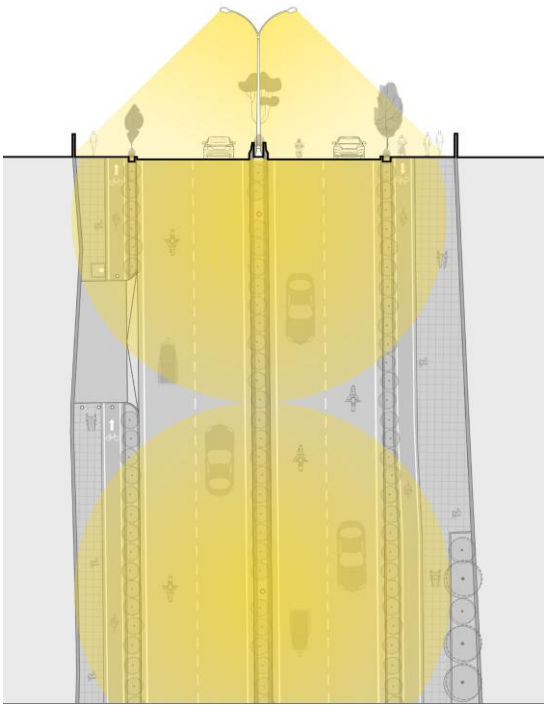
1.1.5.1 Street Lighting

IRC emphasizes adequate and uniform illumination, glare control, high colour rendering, energy efficiency, appropriate pole height and spacing, regular maintenance, environmental considerations, and enhanced safety and security. These guidelines ensure effective, efficient, and sustainable street lighting to improve visibility and reduce crashes and crime. Street lights are to be placed at a maximum distance of 12.5 m to 15 m c/c.

Type 1: Carriageway lighting at median and pedestrian zone lighting on footpath for widths more than 4 m



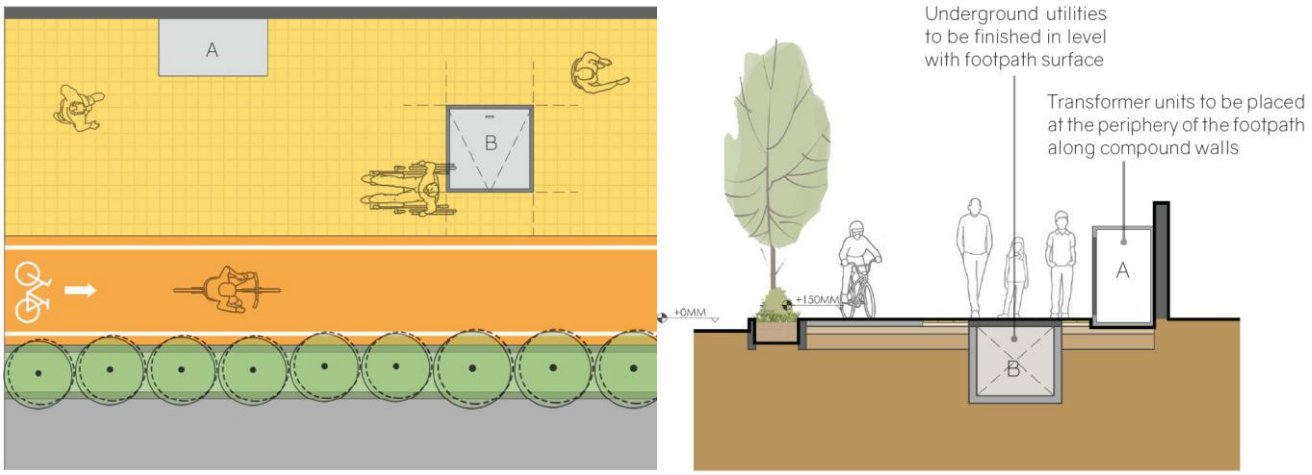
Type 2: Lighting for pedestrian zone below 4 m width at medians



Graphics: High Density Corridor Design Standards Manual, Maya PRAXIS

1.1.5.2 Placement of Utilities

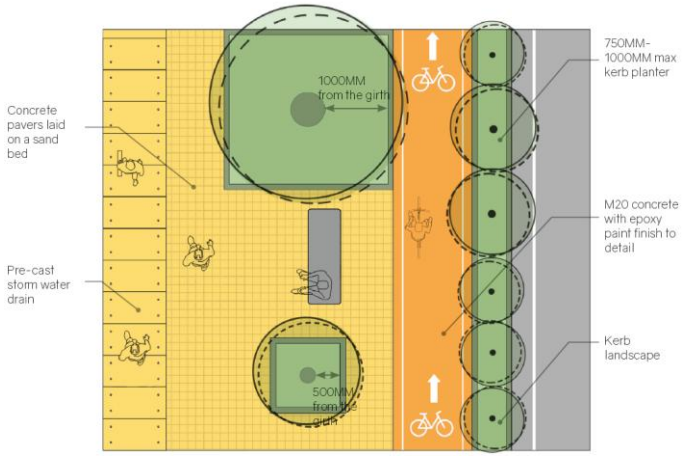
All urban utilities should be placed outside of the clear walking zone. On the ground utilities suhc as transformer units should be placed at the periphery of the footpath along compound walls (A) and all the underground utilities should be finished at level with footpath surface (B).



Graphics: High Density Corridor Design Standards Manual, Maya PRAXIS

1.1.5.3 Tree Grates

Tree grates are installed at the same level of the footpath around a tree. They allow the soil underneath to stay uncompacted and the pedestrians to walk without stepping on the soil.



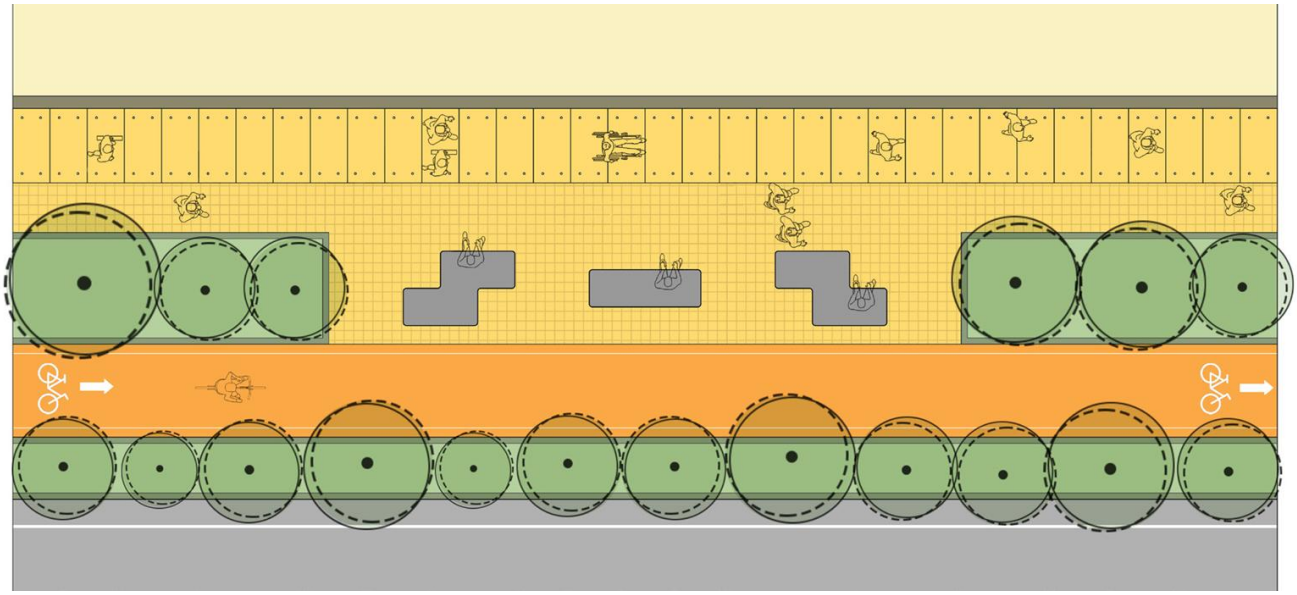
- 1.0 m X 1.0 m or 1.4 m X 1.4 m or 1.8 m X 1.8 m tree pits are to be left for tree roots to breathe. Appropriate tree grates shall be used for the protection of urban trees based on site conditions.
- Tree grates' vertical deviation between paving slabs should not exceed 5 mm.

1.1.5.4 Street Furniture

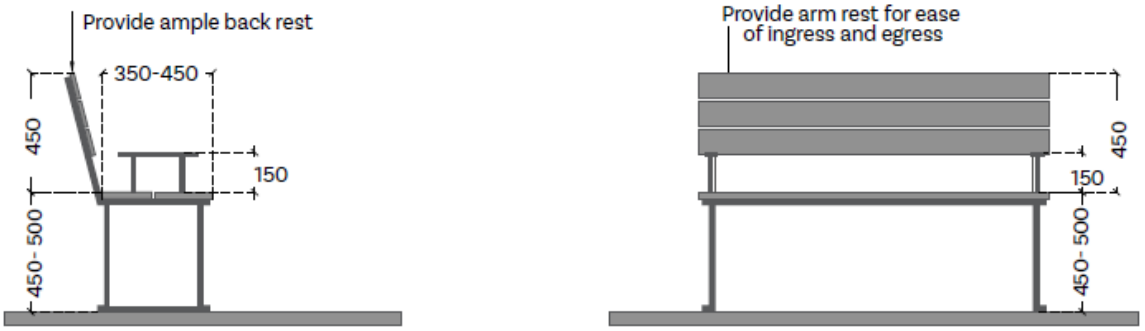
Street furniture serve an immense value to render accessibility support and conveniences to wider user groups but also as dedicated services in external environments. Therefore, their placement in external environments, design, availability and continued maintenance requires sensitivity through design, planning and it's usage by everyone ensuring greater accessibility for all.

If not well coordinated, the same elements could pose as barriers for majority including people with diverse disabilities, walking difficulties, parents with baby strollers and several others. It is therefore recommended to place the diverse street furniture elements in straight line, leaving a clear access path of minimum 900 mm for pedestrian walkability, wheelchair users, etc.

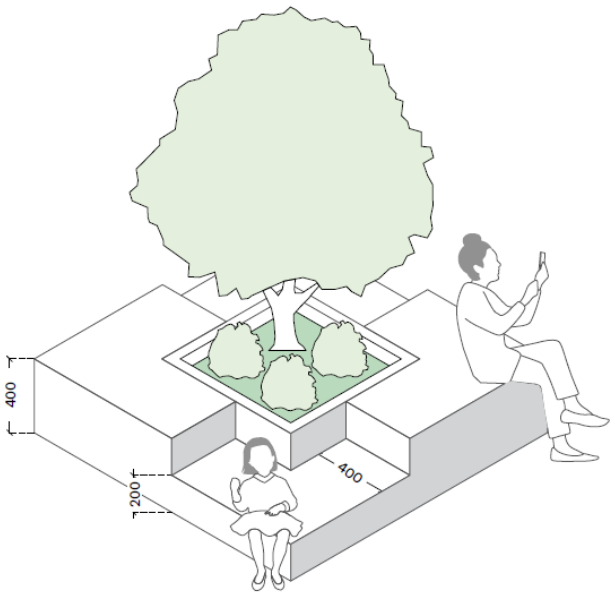
Seating in external environments could be designed either as independent furniture or as built in features responding to the context. In either case, it is important to first identify the location and placement of furniture ensuring that it doesn't hinder the access route for pedestrian mobility including those on wheelchairs or prams, etc.



Seating cluster in the Multi Utility Zone between cycle track and walking zone



Typical Seating Detail



Graphics: High Density Corridor Design Standards Manual, Maya PRAXIS

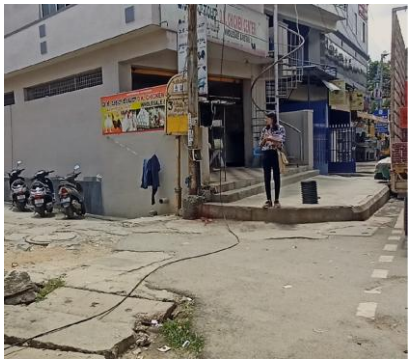
Accessible Street Furniture

1.1.6 CASE STUDY

MIDBLOCKS (CORRIDORS)

Near Sri Maheshwaramma Temple,
Kanakapura Road

EXISTING CONDITIONS



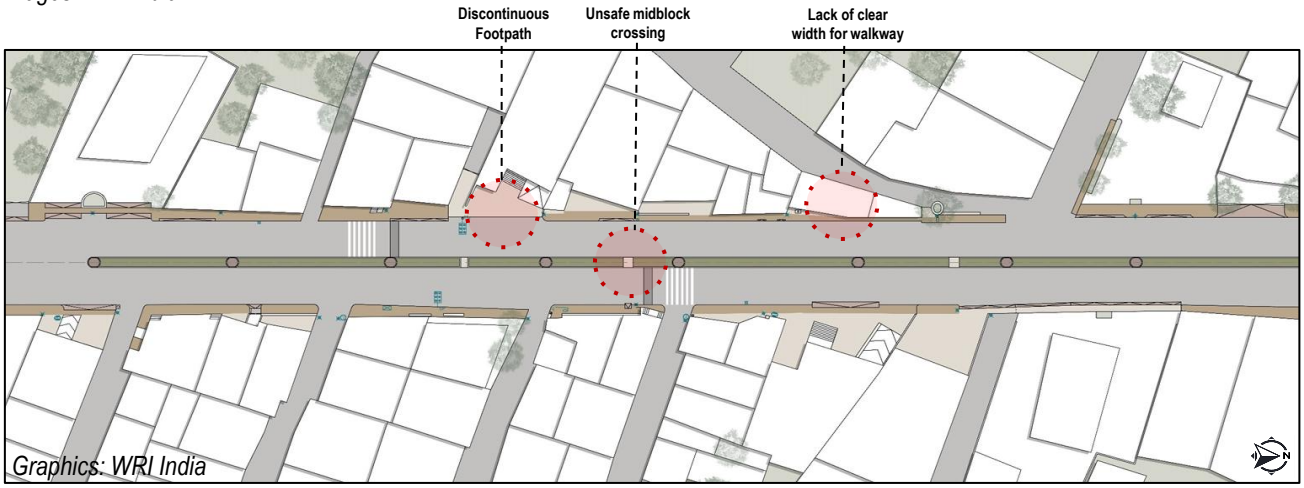
Discontinuous Footpath

Narrow Footpath

Unprotected Pedestrian Crossing

Images: WRI India

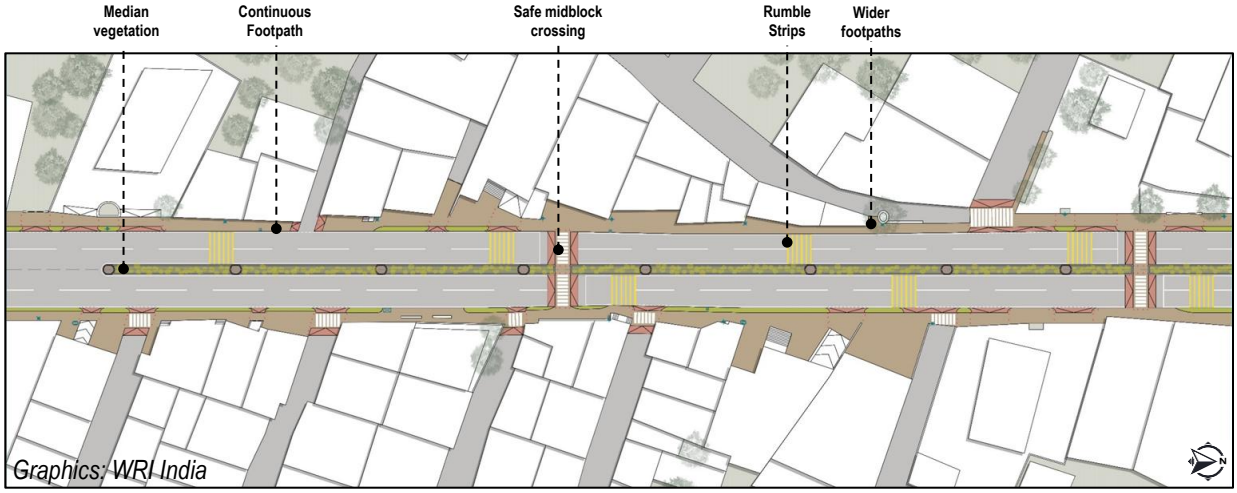
EXISTING PLAN



Graphics: WRI India

This corridor area near Sri Maheshwaramma Temple feels unsafe to the users due to discontinuous footpaths, unsafe midblock crossing and lack of a clear walkway.

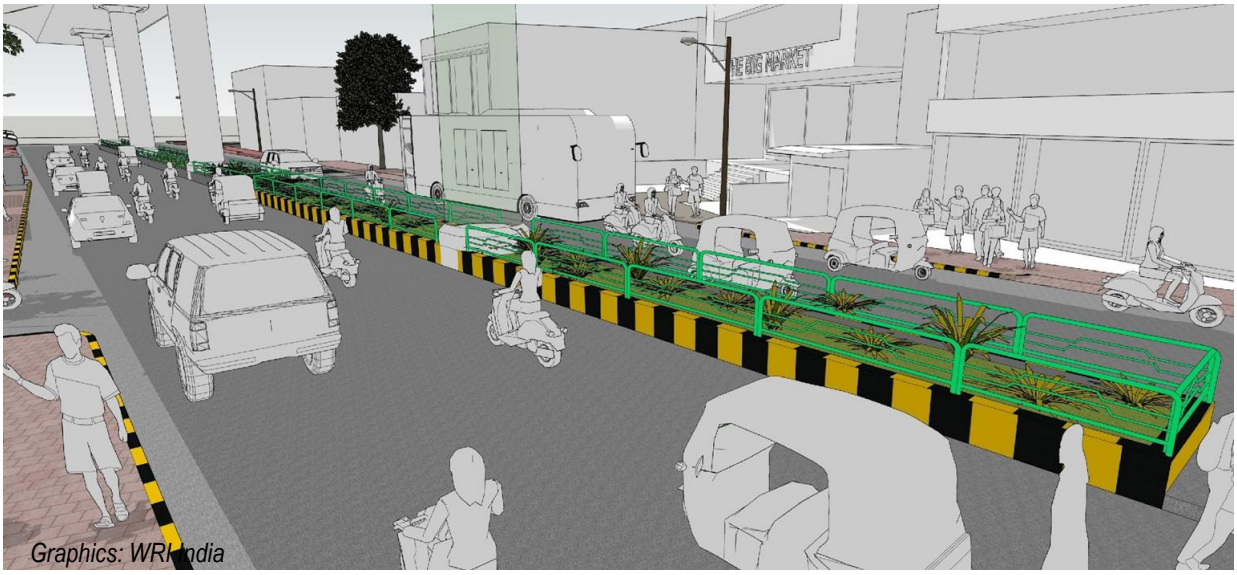
PROPOSED PLAN



Graphics: WRI India

This corridor area can be made safer by design through elements such as wider and continuous footpaths with a clear walkway of 2 m (min) and high raised pedestrian crossing (HRPC), accompanied by rumble strips for speed calming.

EXISTING CONDITIONS



BOLLARDS: They are short posts used to prevent traffic from entering an area. They are used to stop vehicles from entering the footpath and keep pedestrians away from vehicular traffic.

IRC 103:2022

PLANTER/BIOWALES: Vegetation is integrated into pedestrian pathways to enhance aesthetics, provide shade, and improve urban sustainability.

IRC SP: 119-2018

MEDIAN VEGETATION: Vegetation is planted in the center strip of a roadway to enhance aesthetics, improve air quality, and provide a natural barrier for traffic safety.

IRC SP: 21-2009

RAISED PEDESTRIAN CROSSING: An elevated section of the roadway is designed for pedestrians to cross safely, intended to slow down vehicular traffic and improve visibility at crossings.

IRC: 103-2022

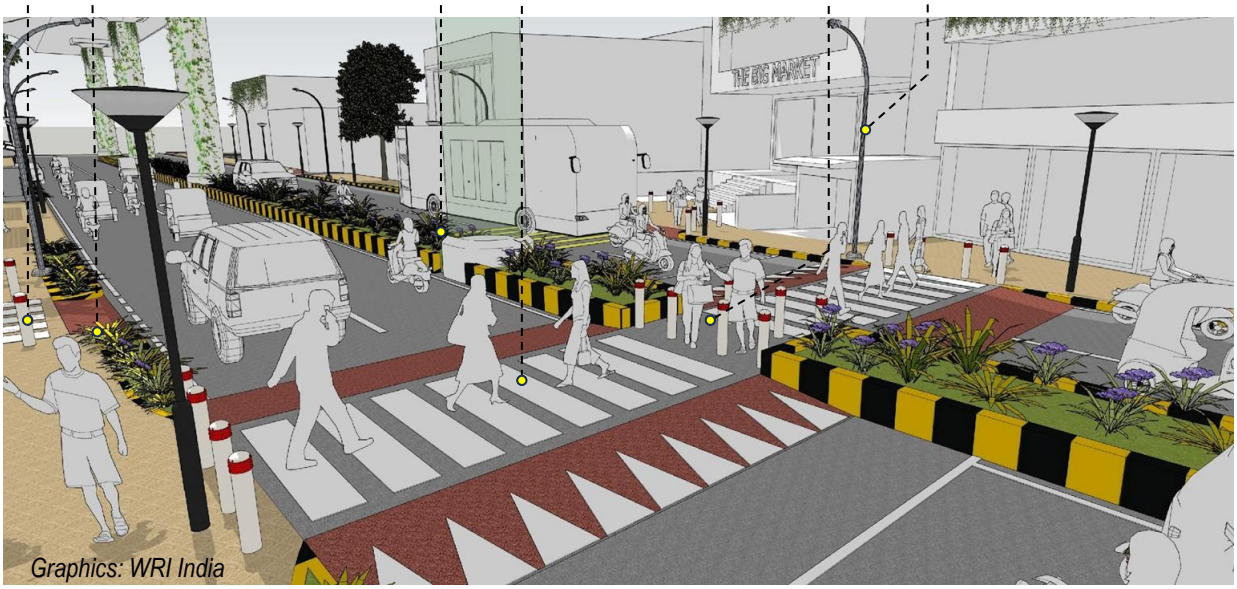
MEDIAN REFUGE: It is a small section of median, completely surrounded by asphalt or other road materials, where pedestrians can stop before finishing crossing a road.

IRC: 103-2022 'Guidelines for Pedestrian Facilities'
IRC: 35-2015 'Code of Practice for Road Marking'

STREET LIGHTS: The level and type of lighting adopted for a street is based mainly on its traffic importance, both vehicular and pedestrian.

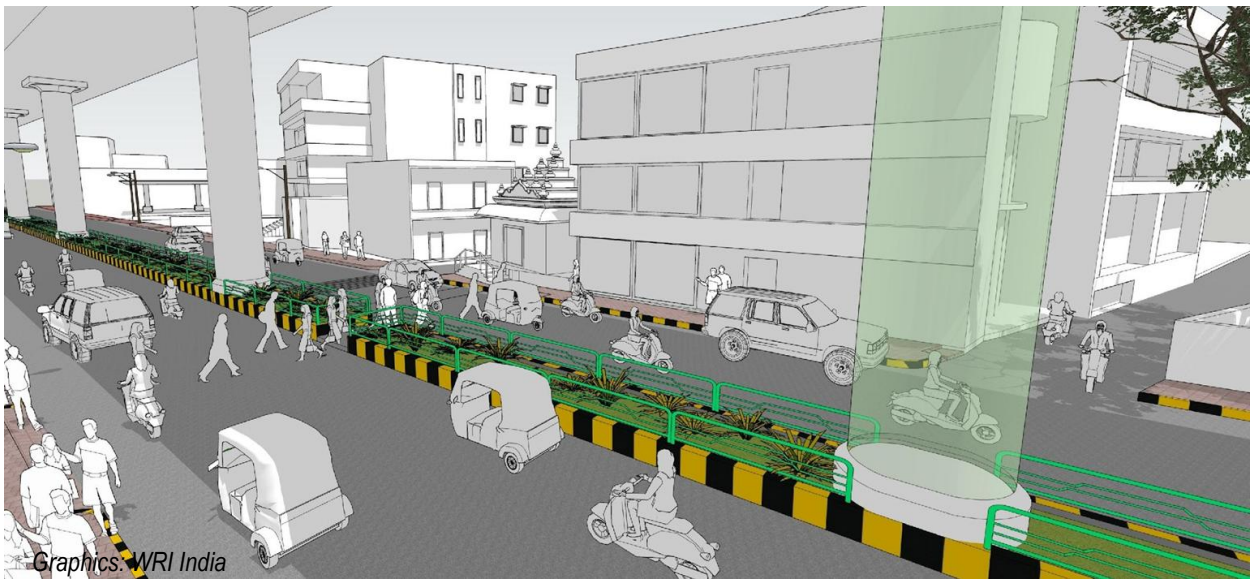
IS 1944-1 and 2 (1970) Reaffirmed 2003

PROPOSED CONDITION



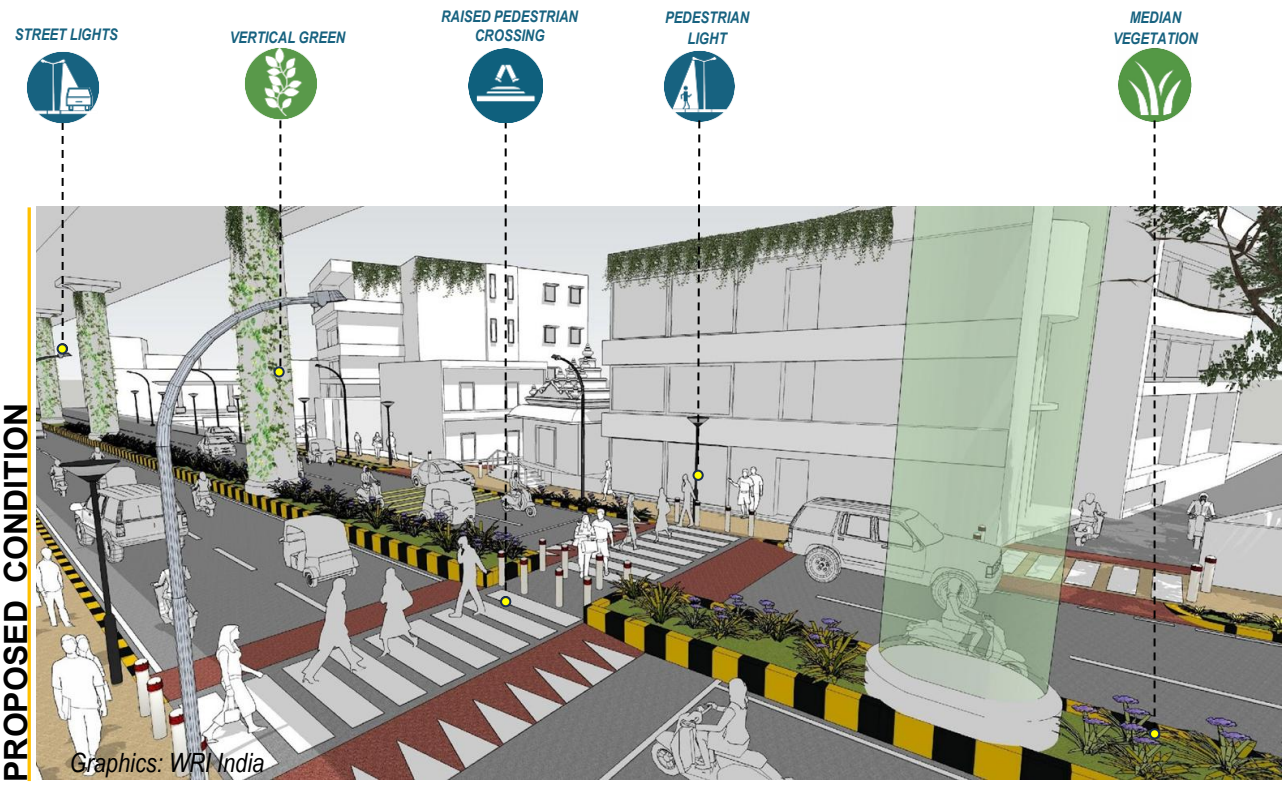
The corridor can have HRPCs, where there is huge crossing demand. The crossing needs to be accompanied by painted markings, pedestrian lights, signages, raised crossing, median refuge and rumble strips to make the street safer for pedestrians.

EXISTING CONDITIONS



This corridor area feels unsafe because of insufficient street lights and pedestrian lights. There is high-risk for pedestrians due to lack of speed calming and pedestrian crossings.

PROPOSED CONDITION



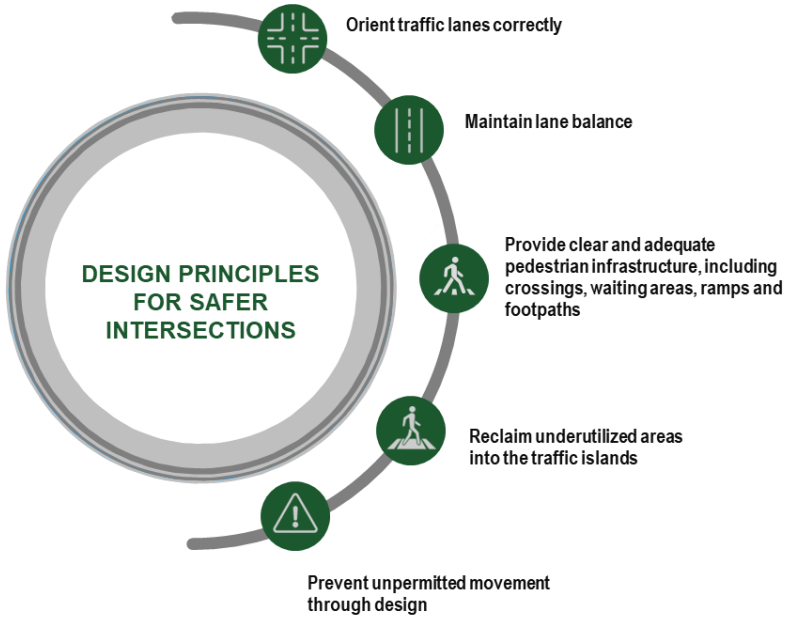
This corridor area can be made safe through the provision of pedestrian lights and speed calming measure such as HRPC raised pedestrian crossing, median refuge and bollards.

1.2 JUNCTIONS

Designing junctions is critical for ensuring smooth traffic flow, reducing crashes, and promoting safety for all road users, including pedestrians and other vulnerable road users.

A well-designed junction considers factors such as visibility, pedestrian and traffic volume, and needs of all transportation modes.

The primary goal should be to minimize conflicts between vehicles and pedestrians while accommodating different road users efficiently.



1.2.1 Typologies of a Junction

Major Junctions

Above 1000 sqm of area OR complex geometry of more than 5 arms including at least 1 arterial or sub-arterial road

Junctions

Above 250 sqm till 1000 sqm of area OR complex geometry of more than 5 arms including collector or local road

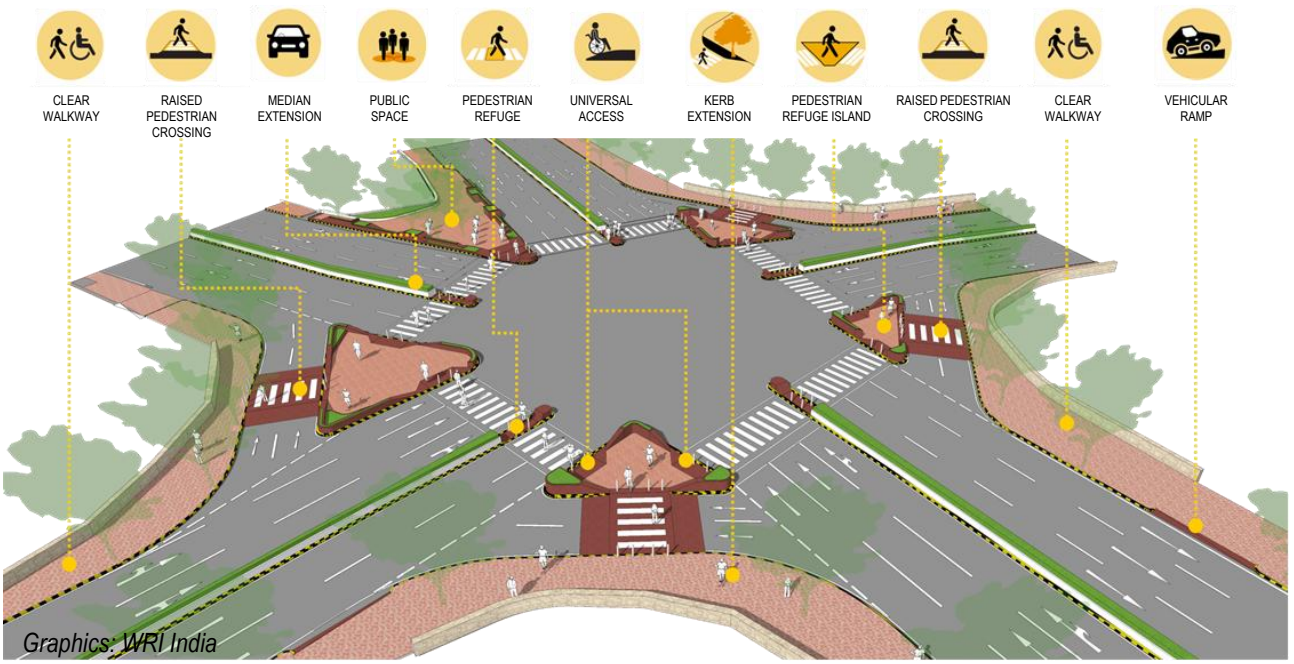
Minor Junctions

Below 250 sqm of area OR intersection of local roads with another local road or collector road

	ARTERIAL	SUB-ARTERIAL	COLLECTOR	LOCAL	MORE THAN 5 ARMS
ARTERIAL	MAJOR JUNCTION	MAJOR JUNCTION	JUNCTION	JUNCTION	MAJOR JUNCTION
SUB-ARTERIAL	MAJOR JUNCTION	MAJOR JUNCTION	JUNCTION	MINOR JUNCTION	MAJOR JUNCTION
COLLECTOR	JUNCTION	JUNCTION	JUNCTION	MINOR JUNCTION	JUNCTION
LOCAL	JUNCTION	MINOR JUNCTION	MINOR JUNCTION	MINOR JUNCTION	JUNCTION
MORE THAN 5 ARMS	MAJOR JUNCTION	MAJOR JUNCTION	JUNCTION	JUNCTION	

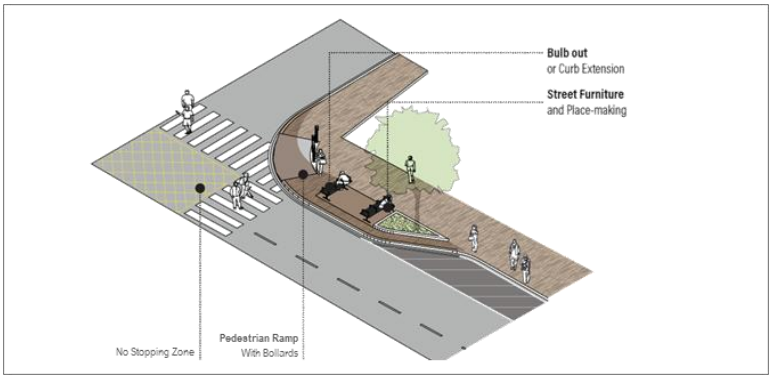
1.2.2 Components of a Junction

The following pedestrian infrastructure should be incorporated to make junctions safer by design.



Graphics: WRI India

1.2.3 Kerb Extensions



Graphics: Lekshmy Hirandas and Rohit Tak/ WRI India

Bulb out or kerb extensions provide additional space along sidewalks, decrease pedestrian crossing distance, provide an area for landscape, slow vehicular speeds, and reduced kerb radii to facilitate safe turning movements.

WRI India

1.2.4 Turning Radii

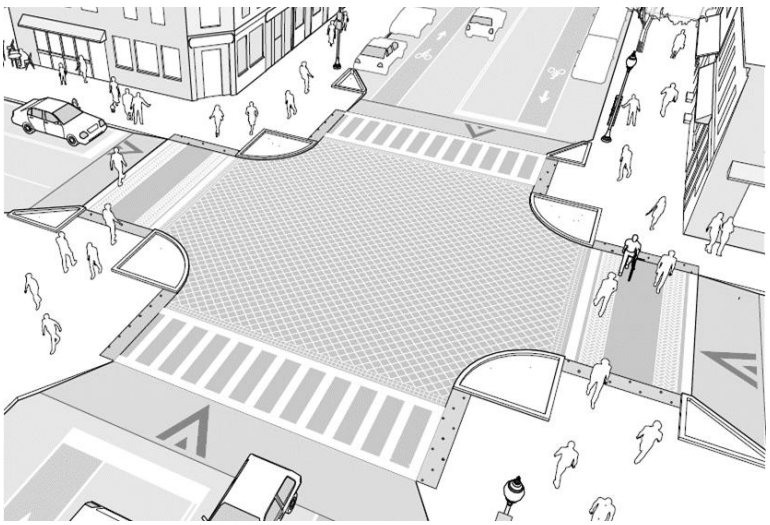
Graphics: Chetan Sodaye and Akhila Suri/ WRI India

It is the radius of the circular turn a vehicle is capable of making.

IRC SP 041-1994, 4.6

The minimum turning radius for a vehicle governs the design. In urban areas, if the curve radii increases, the pedestrian crossing distance increases. Since this has pedestrian safety implications, this should be kept in view while deciding on the turning radius to be provided. However, to ensure efficient traffic operations, a common radii of 4.5 m to 7.3 m for passenger cars and 9 m to 15 m for buses and trucks is recommended. The final kerb radius should be selected considering the a) type/ hierarchy of intersection, b) space available and c) existing road layout and geometry.

1.2.5 Raised Intersections



Graphics: Low Speed Zone Guide, WRI

The intersection area is raised to the same level as the surrounding footpath. Ramps are constructed for access to the raised intersection area.

WRI India

Slope of the entrance ramps for motorized traffic can be steep or shallow, depending on target speeds, but it is normally raised to the vertical level of the kerb.

Use different paving materials to further draw attention to raised intersections. Appropriate warning signs and roadway markings should accompany raised crossings.

1.2.6 Speed Calming Measures

Speed Humps

Graphics: Chetan Sodaye/ WRI India

It is a ridge set at intervals on a road surface to control the speed of vehicles.

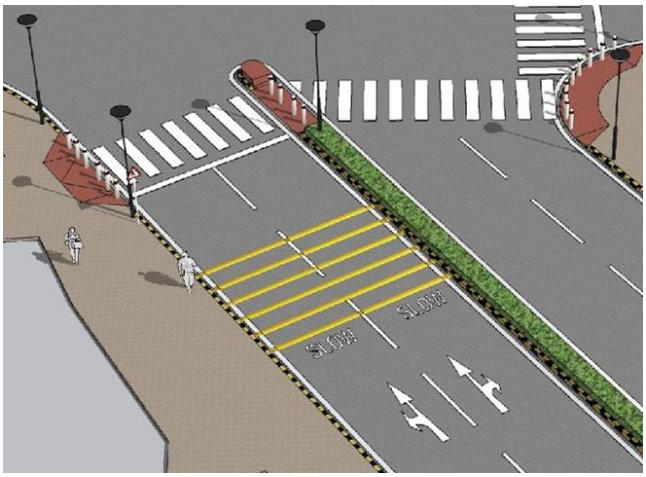
IRC: 99-2018, WRI India

Speed humps shall be placed in advance of the unsignalized pedestrian crossing, forcing vehicles to slow before the pedestrian crossing and enhance the safety of pedestrians.

Speed breakers are formed basically by providing a rounded (of 17 m radius) hump of 3.7 m width and 0.1 m height for the preferred advisory crossing speed of 25 km/h for general traffic.

The distance between the edge of pedestrian crossing to the edge of the speed hump to be 1.5 m.

Rumble Strips



Graphics: Chetan Sodaye/ WRI India

They are used to reduce the speed of vehicles on the main carriageway

IRC: 99-2018

Thermoplastic marking of 300 mm width and 5 mm height and 600 mm apart (one set is of 6 strips)

The safety pattern recommended in IRC:99-2018 is to be followed

Raised Pedestrian Crossings (HRPCs)

Graphics: Chetan Sodaye/ WRI India

Raised crossings enhance the safety of pedestrians crossing to the opposite side at unsignalized locations. They compel drivers to travel at a lower speed before the crossing

IRC: 99-2018, WRI India

Raised pedestrian crossings are to be on the same level as the footpath.

Paving material of raised pedestrian crossings to be visually different from the carriageway.

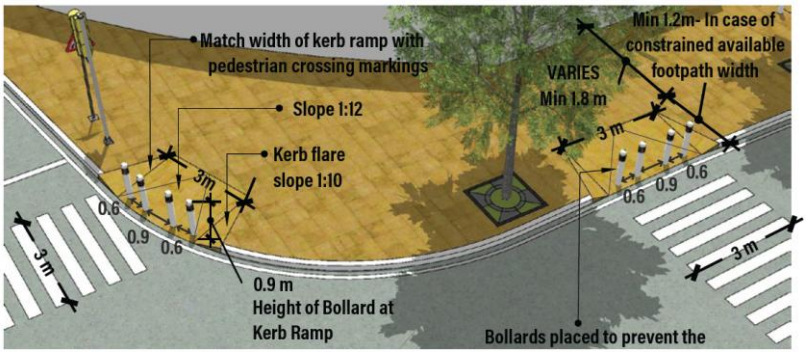
1.2.7 Kerb Ramps

They are used to provide easy access for pedestrians and wheelchair users to the pedestrian crossing.

IRC: 103 - 2022, WRI India

Standard kerb ramps are cut back into the footpath (flush with roadway), at a gradient not greater than 1:8 (i.e. 1.2 M for 150 MM height of kerb) with flared sides 1:6 (i.e. 1 M for 150 MM height of kerb) providing transition in three directions.

Width of the kerb ramp should not be less than 1.2 M. 2 M clear walking space must be maintained behind the kerb ramp to enable unobstructed pedestrian movement along the footpath.

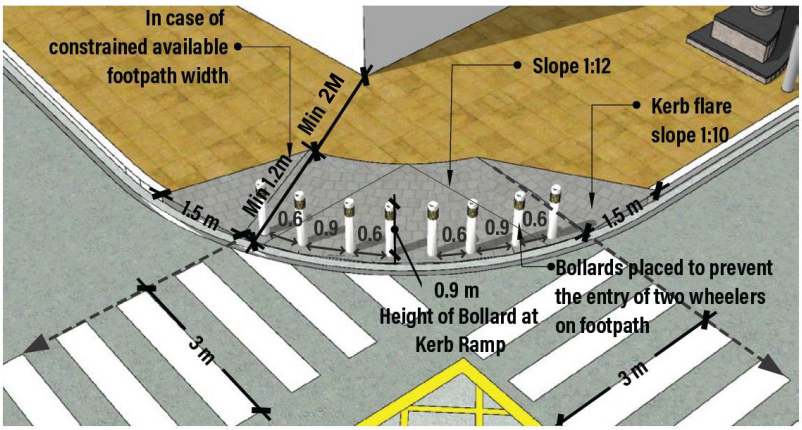


Graphics: Shubhra Kansal and Akhila Suri/ WRI India

Type 1

When pedestrian crossings are located at a distance from each other

Individual kerb ramps with bollards are provided at each crossing

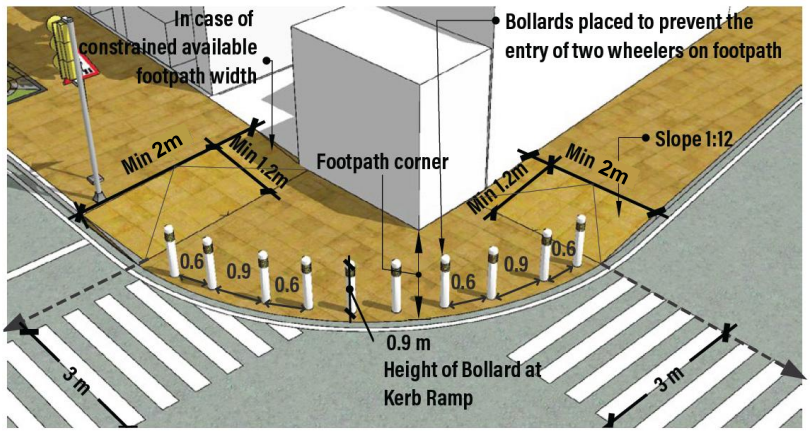


Graphics: Shubhra Kansal and Akhila Suri/ WRI India

Type 2

When pedestrian crossings meet each other at the intersection

A longer kerb ramp common to both crossings can be provided.



Graphics: Shubhra Kansal and Akhila Suri/ WRI India

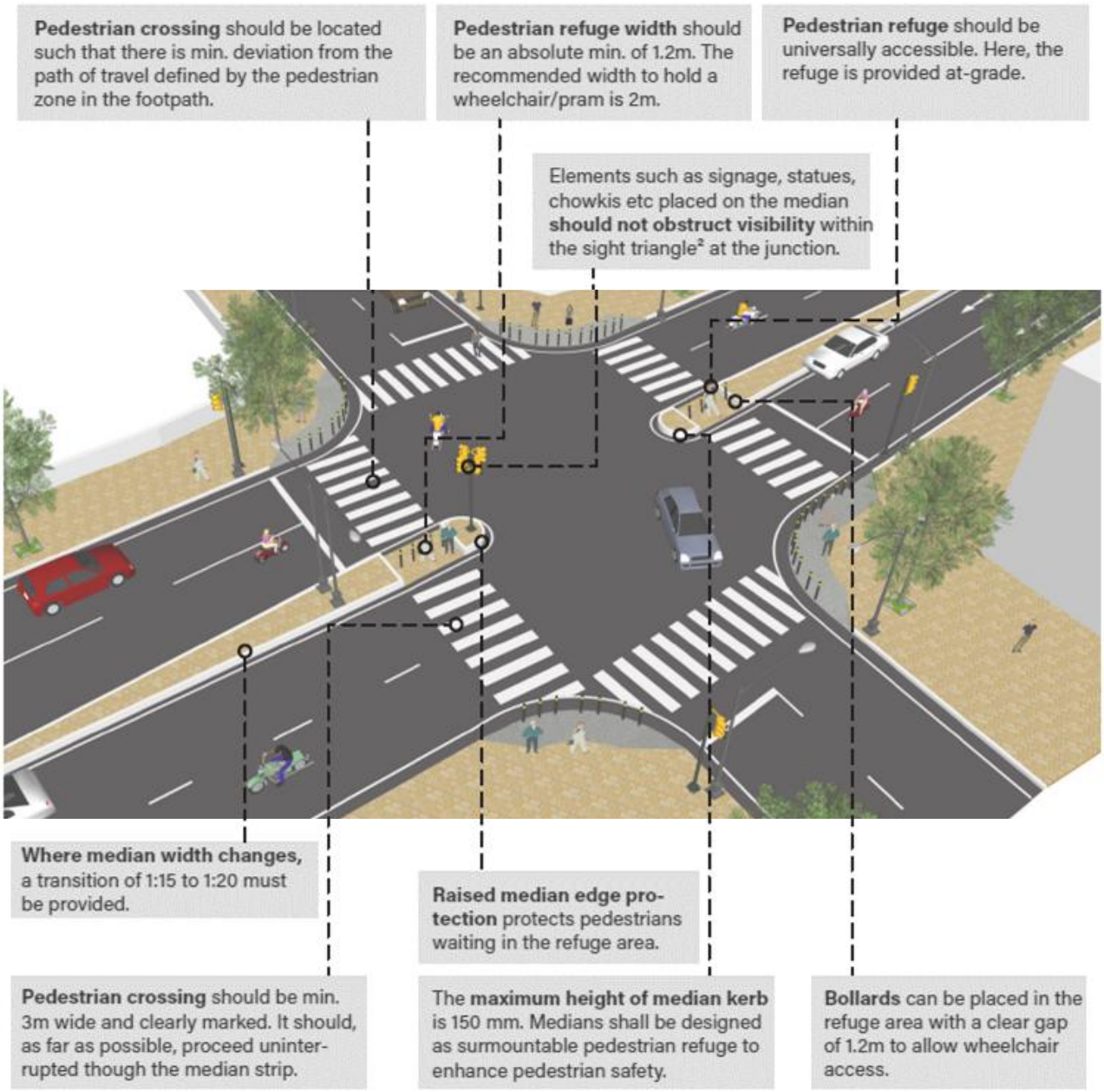
Type 3

When there is insufficient footpath width to incorporate a typical kerb ramp

If the clear width available at the intersection corner is less than 3m, then for better space utilization, the entire footpath area after the pedestrian crossings can be brought to the same level as the carriageway. In this scenario, the footpath itself can ramp down to this common area.

1.2.8 Pedestrian Safety Elements

At junctions, pedestrian crossings provide designated places for people to cross. The median design at these locations can help protect pedestrians as they wait in the refuge area.



Graphics: Urban Circle for WRI India

1.2.8.1 Pedestrian Crossings

They are designed to keep pedestrians together so they can be seen by motorists and can cross safely across the flow of vehicular traffic.

IRC: 103 - 2022

The width of pedestrian crossing should range from 3.5m to 4.5 m. All unsignalized pedestrian crossings should be accompanied by speed humps.

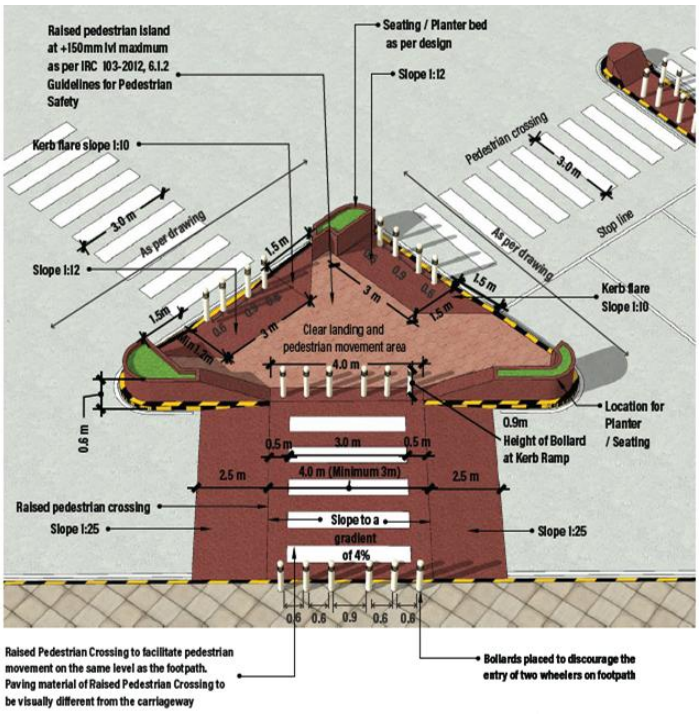
1.2.8.2 Pedestrian Refuge Areas

a. Refuge Islands

It is an area reclaimed from carriageway unused by vehicular movement for pedestrian access and pause point, surrounded by asphalt or other carriageway materials, where pedestrians can stop before finishing crossing a road.

IRC: 103-2022 'Guidelines for Pedestrian Facilities',
IRC: SP-41 'Guidelines for the Design of At-Grade Intersections in Rural and Urban Areas',
WRI India

Refuge islands are provided to channelize vehicular traffic while also providing protected refuge areas for pedestrians. As a thumb rule, at least 70% of the island should be open for pedestrian movement. Planters, if provided should not be taller than 0.6m. There are broadly two types of refuge islands.

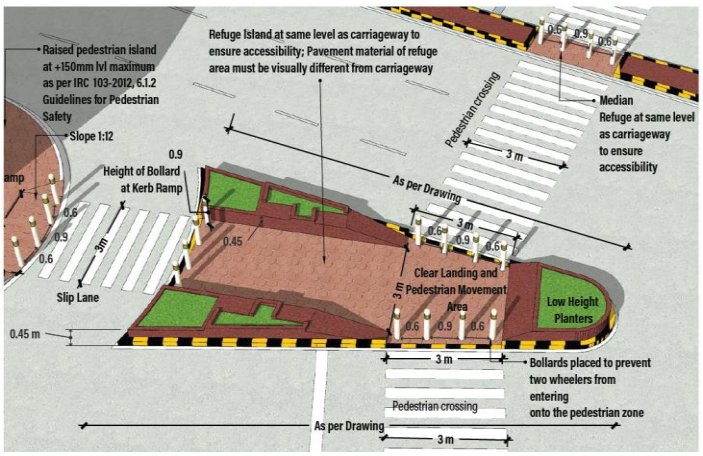


Graphics: WRI India

Type 1

At Footpath Level

Kerb ramps are provided to access the island from the pedestrian crossing on the carriageway. A clear landing and pedestrian movement area should be provided on the island.



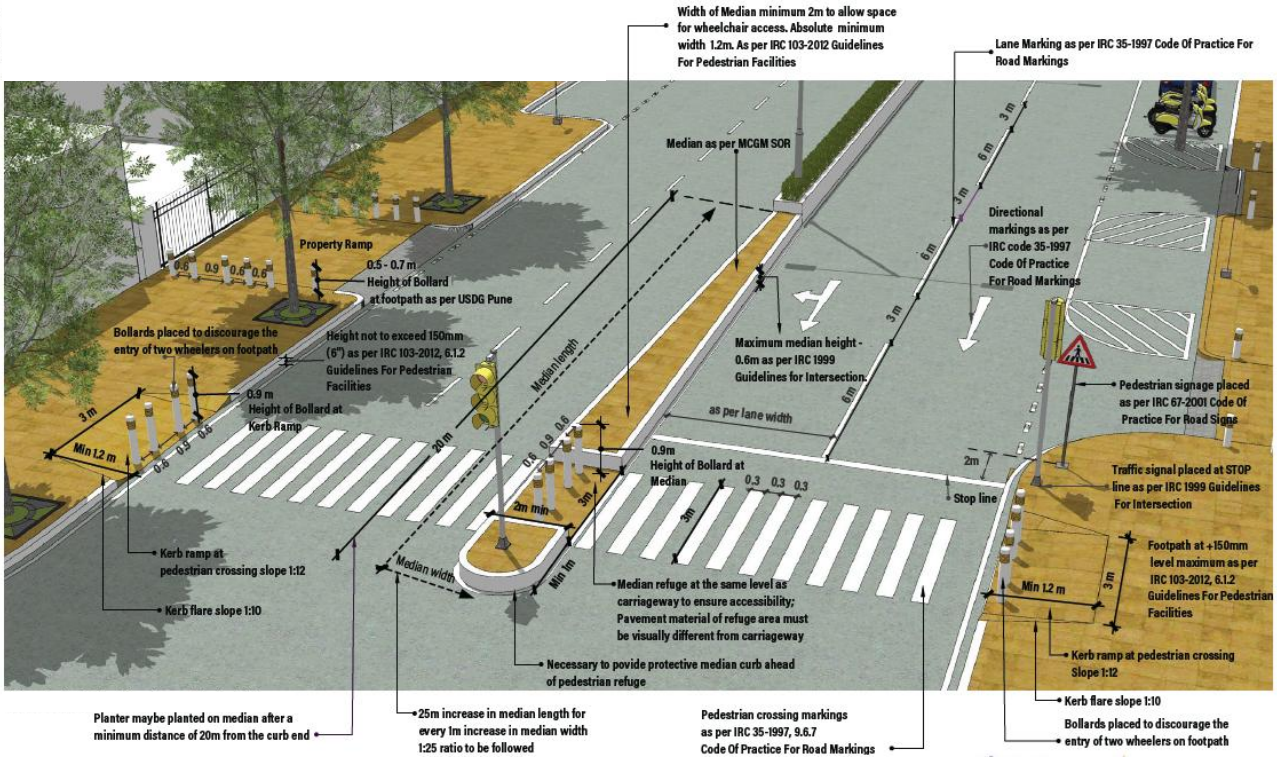
Graphics: WRI India

Type 2

At Carriageway Level

For smaller islands where there is insufficient width for two kerb ramps, the level can be
maintained at carriageway level and protected from vehicular traffic by means of bollards.

b. Median Refuge



Graphics: Shubhra Kansal and Akhila Suri/ WRI India

It is a small section of median, completely surrounded by asphalt or other road materials, where pedestrians can stop before finishing crossing a road.

IRC: 103-2022 'Guidelines for Pedestrian Facilities'
IRC: 35-2015 'Code of Practice for Road Markings'
IRC: 93-1985 'Guidelines on Design and Installation of Road Traffic Signals'
IRC: SP 041-1994 'Guidelines for the Design of At-Grade Intersections in Rural and Urban Areas'

The refuge area must be the same width and at the same level of pedestrian crossing. 2 m wide refuge area to be maintained. Bollards must be placed along the center-line along the median.

1.2.8.3 Bollards

It is a short post used to prevent traffic from entering an area.
IRC: SP 041-1994
IRC: 103-2022

Bollards are used to stop vehicles from entering the footpath and keep pedestrians away from vehicular traffic.

- Spacing between two bollards for universal access should be a min. of 0.9 m up to 1.2 m. Within a single set of bollards, at least a single pain of bollards must allow wheelchair access. Other pairs are recommended to be spaced at 0.6 m to prevent two-wheeler movement.
- Bollards with 0.5 - 0.7 m high from the ground level and be identifiable with the provision of reflective tapes.
- These must be placed at least 150 mm setback from the edge of the kerb.
- It is recommended to have 100 mm diameter circular bollards.

Bollards need to be positioned carefully through proper planning and understanding to ensure that they don't pose as barriers to wheelchair users, ambulant disabled, parents with strollers, elderly and several other kinds of user categories. Bollards should not be positioned within an access route and should be identifiable by using contrasting colours, reflective bands or materials around the neck. Linking bollards with ropes or chains shall be avoid as this can present a hazard to people with visual impairments.

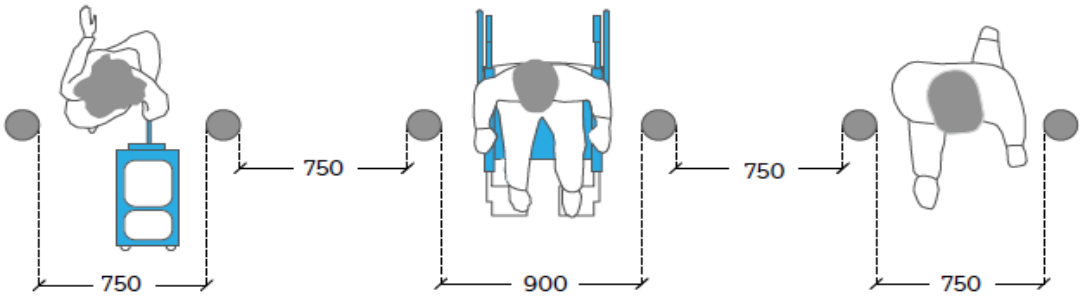


Fig a: Plan

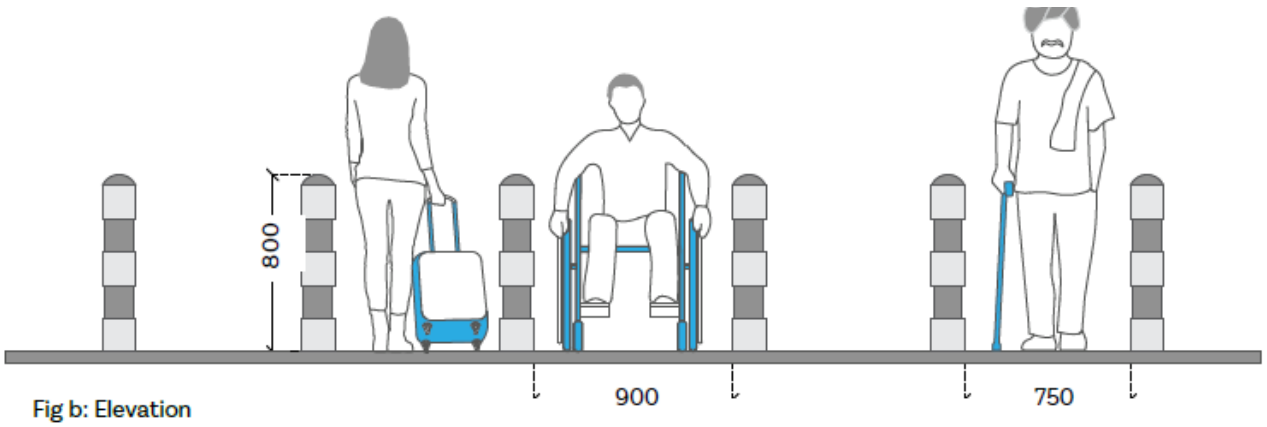


Fig b: Elevation

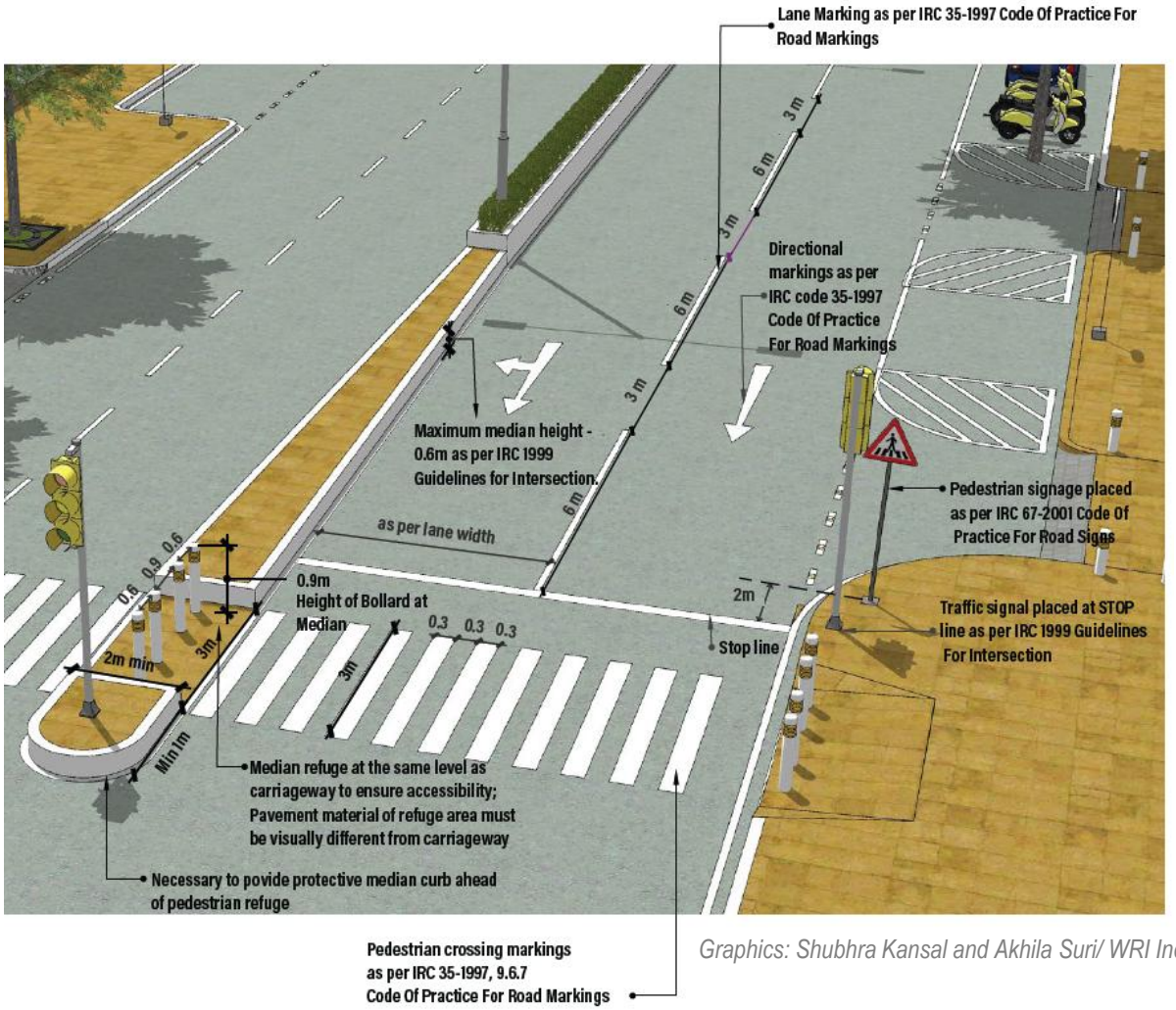
Graphics: Harmonised Guidelines & Standards for Universal Accessibility in India, NIUA

Bollard Details

Image: Harmonised Guidelines & Standards for Universal Accessibility in India, NIUA

Typical bollard placement for accessible footpath with tactile pavers. Location: Church Street, Bengaluru

1.2.9 Road Markings



Graphics: Shubhra Kansal and Akhila Suri/ WRI India

a. Traffic Lane Lines

These markings help the driver to identify the footpath or median edge and to delineate different travel lanes within the carriageway.

IRC: 35-2015

- Footpath edge marking: white solid line
- Lane marking: white broken line
- Median edge line: white solid line

b. Pedestrian Crossing

They are used indicate permissible areas in the carriageway where pedestrians can cross most safely across the flow of vehicular traffic.

IRC: 35-2015

- Pedestrian crossing shall be 500 mm wide solid white line with 3 to 5 m line segment and a 500 mm gap.
- Zebra crossing starts not less than 500 mm and not more than 1.25 m from the edge of the carriageway.
- 15 mm square or circular-shaped cat eye may be used to enhance safety during night time and it should protrude 15-25 mm from the surface.

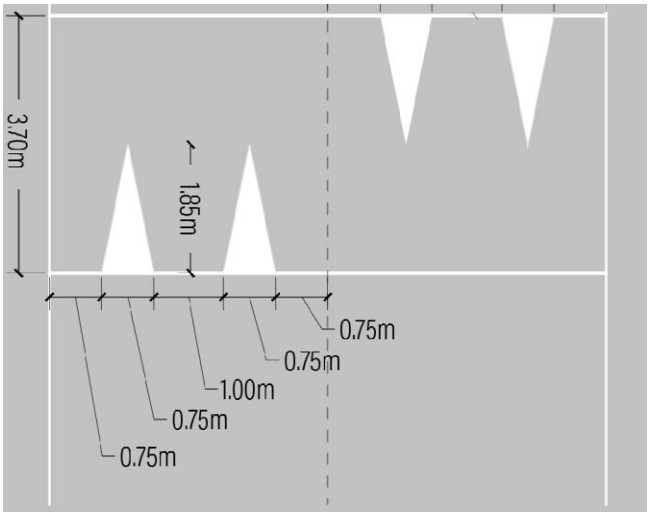
c. Stop Line

This is a line along the road, marking the point at which a vehicle must stop, in junctions with traffic lights only.

WRI India, IRC: 35-2015

- 300 mm wide white solid line
- Stop line to be placed 1.5 m in advance of the pedestrian crossing.
- 1.25 m high STOP marking to be adopted in the direction of travel.

d. Speed Hump Marking



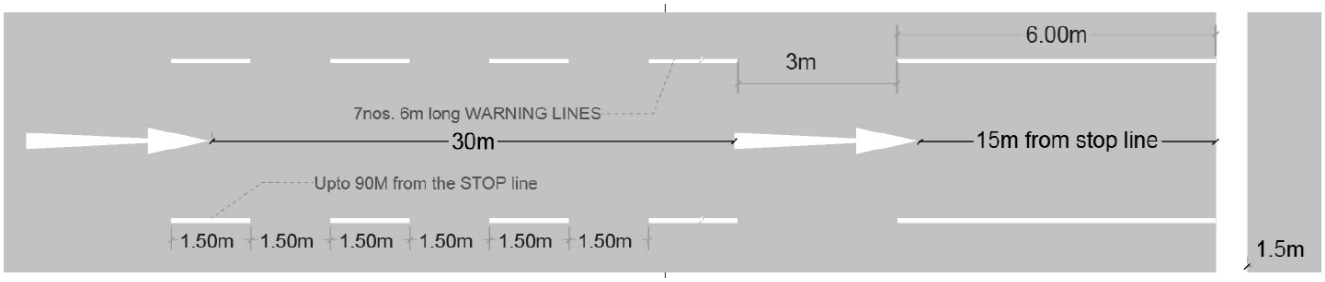
Graphics: WRI India

They are used to indicate the presence of a speed hump so that vehicles may slow down in advance.

IRC: 35-2015

Speed breakers should be painted with white paint to give additional visual warning.

e. Directional Arrows



Graphics: WRI India

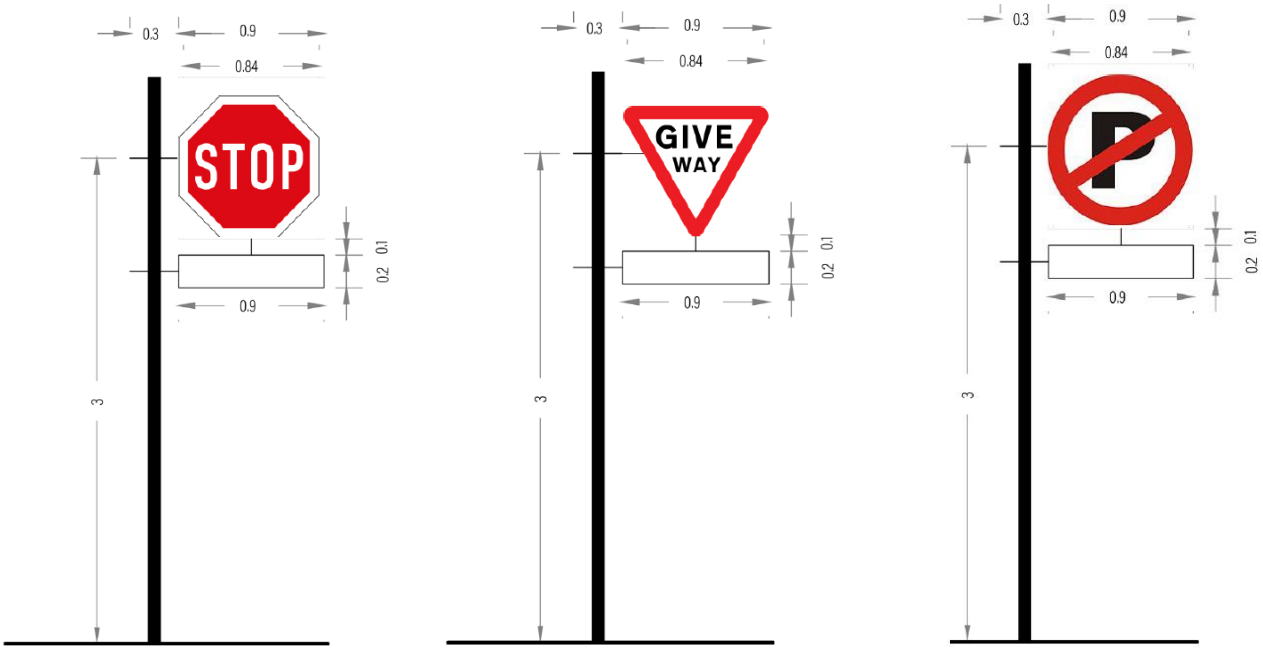
They are used to indicate the direction of flow of traffic in each traffic lane.

IRC: 35-2015

- 15 m from the stop line.
- Second arrow to be placed 30 m from the first arrow.

Note: At the slip lane, 7 m should be considered from the edge of the pedestrian crossing.

1.2.10 Signages



Graphics: WRI India

a. STOP Sign

It is a mandatory traffic sign to notify drivers that they must come to a complete stop and make sure no other road users are coming before proceeding.

IRC: 67-2012, 14.5.5

The stop sign should be sited 1.5 m to 6 m in advance of the stop line.

The sign shall not be used at intersections where traffic signals are installed.

b. GIVE WAY Sign

It is a mandatory traffic sign that indicates that each driver must prepare to stop if necessary to let a driver on another travel lane approach.

IRC: 67-2012, 14.6.4

This sign is used to slow down or stop when necessary to avoid interfering with conflicting traffic.

This sign is recommended to be sited 1.5 m to 12 m in advance of the speed hump and side streets.

c. No Parking

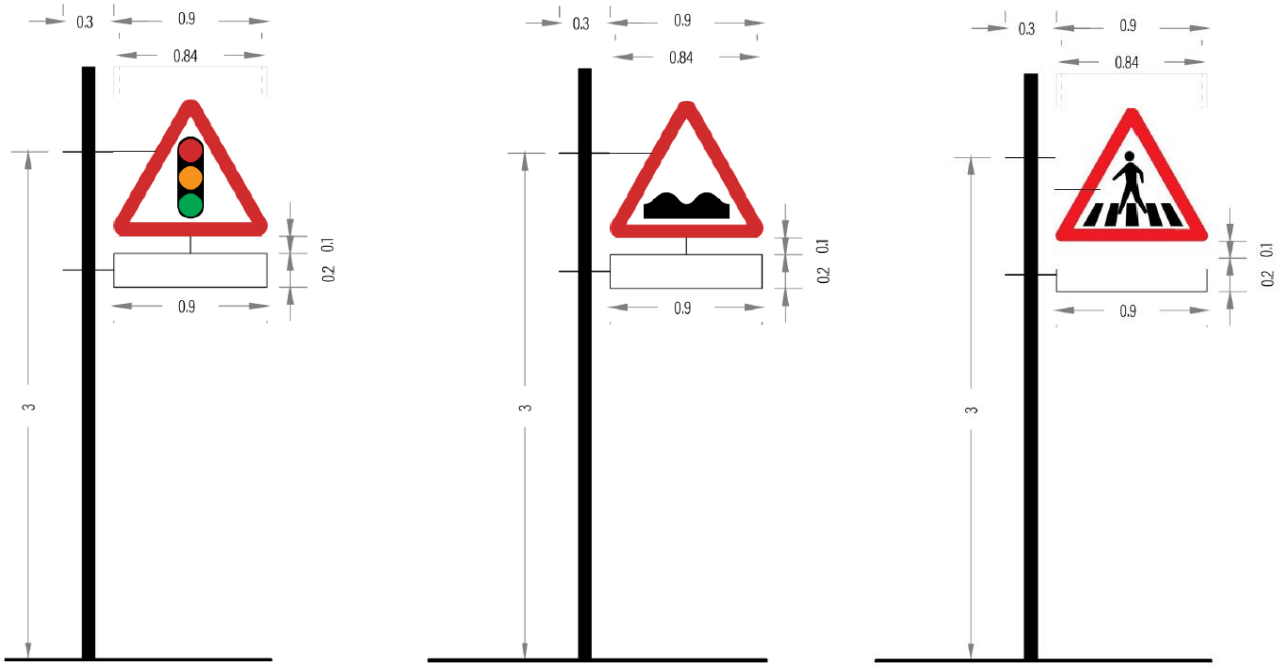
It is a mandatory traffic sign that indicates areas where parking is prohibited.

IRC: 67-2012, 14.8.5

Signs should be erected within 25 m of the start and end of the prohibition. The “No Parking” sign is placed parallel to the kerb facing the carriageway and sited approximately at 100 m intervals.

Where signs are used without road markings, they should be placed strategically rather than at fixed intervals. The aim should be that wherever drivers might be tempted to stop, they should be able to see a sign.

The spacing between consecutive signs, whether or not they are on the same side of the road, should be no more than 30 m.



Graphics: WRI India

d. Cautionary Signs

These signs are meant to warn the driver about the hazards or situation lying ahead on the road.

IRC: 67-2012, Table 15.1

Side Road, Y-intersection, Cross Road, Roundabout, Traffic Signals, Traffic Signals, Major Road Ahead, Staggered Intersection, Merging Traffic Ahead, Narrow Road Ahead, Road Widens, Reduced Carriageway, Gap in Median, Pedestrian Crossing, School Ahead, Speed Breaker and Hazard Marker signs shall be placed 45 m in advance of the hazard.

e. Hump Ahead sign

It is a cautionary traffic sign that indicates that each driver must prepare to slow down due to the presence of a speed hump.

IRC: 35-2015

The sign should be located 40 m in advance of the center of the speed breaker.

Lateral placement of the sign should be 600 mm setback on kerbed roads.

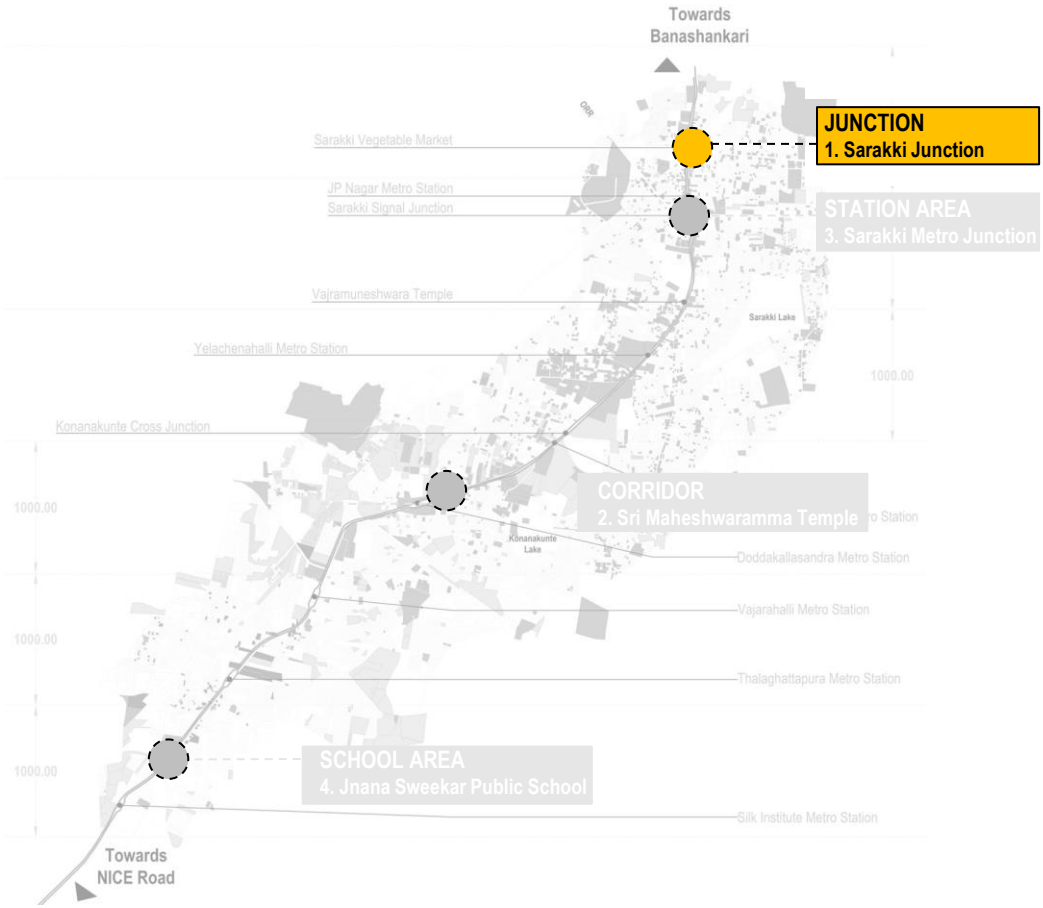
f. Pedestrian Crossing

It is a cautionary traffic sign that indicates the presence of uncontrolled pedestrian crossing.

IRC: 67-2012, 15.27 Table 15.1

The sign should be erected in advance on both approaches to uncontrolled pedestrian crossings.

This is absolutely essential when visibility of the crossing is impaired by a bend or hump in the road.



1.2.11 CASE STUDY

JUNCTIONS

Near Sarakki Market, Kanakapura Road

EXISTING CONDITIONS

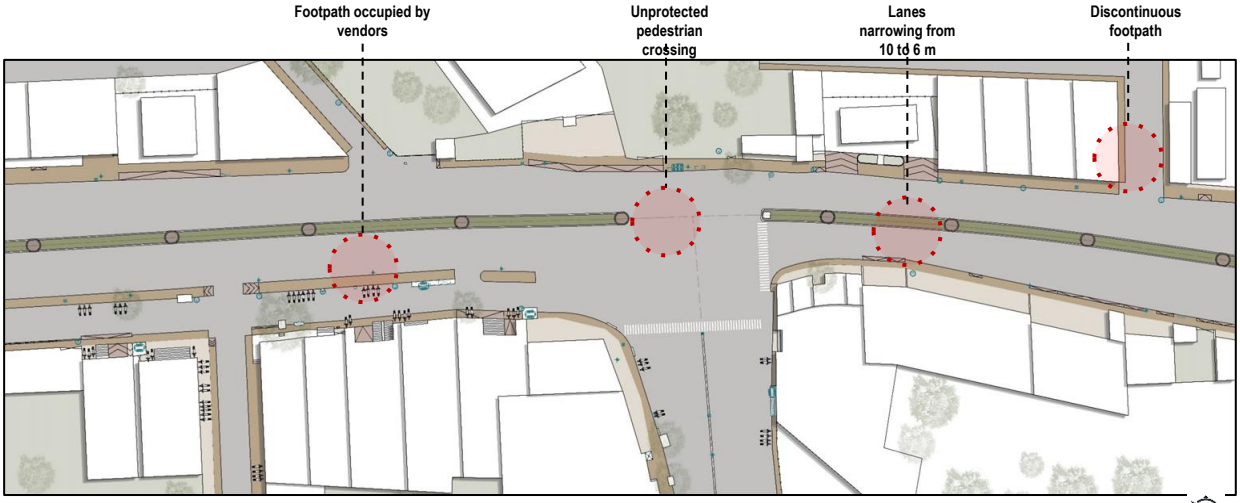
Broken Footpath

Narrow Footpath

Unprotected Pedestrian Crossing

Images: WRI India

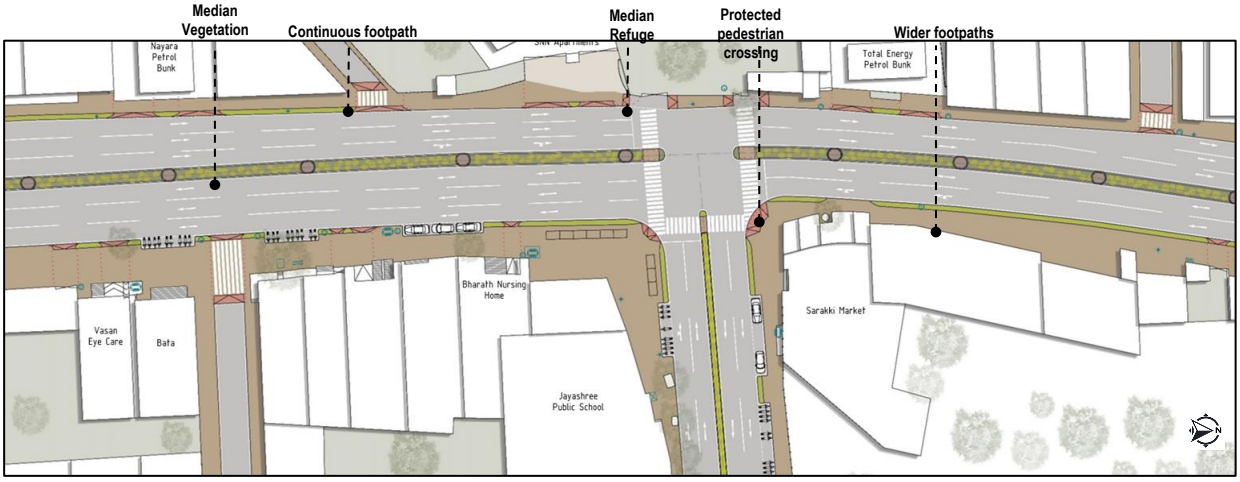
EXISTING PLAN



Graphics: WRI India

This market area of Sarakki feels unsafe to pedestrians due to encroachment on the footpath by vendors, unprotected pedestrian crossings, discontinuous footpath, and inconsistent lane widths, all of which force users to walk on carriageway.

PROPOSED PLAN



Graphics: WRI India

This market area can be made safer and more vibrant through the provision of continuous and wider footpaths, protected pedestrian crossings, and designated vendor and parking areas.

EXISTING CONDITIONS

Graphics: WRI India

***PEDESTRIAN LIGHT*:** Outdoor lighting fixtures are installed along the roads, sidewalks, and public spaces to enhance visibility, safety, and security during night time.
SP 72: 2010

***PEDESTRIAN CROSSING*:** It is designed to keep pedestrians together so they can be seen by motorists and can cross most safely across the flow of vehicular traffic.
IRC 103:2022

***BOLLARDS*:** It is a short post used to stop vehicles from entering the footpath and enhance pedestrian safety.
IRC SP 041-1994 IRC 103:2022

PLANTS/BIOSWALES: Vegetation is planted in the center strip of a roadway to enhance aesthetics, improve air quality, and provide a natural barrier for traffic safety.
IRC SP: 21-2009

***MEDIAN REFUGE*:** This is a small section of the median, completely surrounded by asphalt or other road materials, where pedestrians can stop before finishing crossing a road.
IRC: 103-2022 'Guidelines for Pedestrian Facilities'
IRC: 35-2015 'Code of Practice for Road Marking

***STREET LIGHTING*:** Fixtures are installed along the median strip of a road to improve visibility, enhance safety, and guide traffic, especially at night.
IS 1944-1 and 2 (1970) Reaffirmed 2003

PROPOSED CONDITIONS

Graphics: WRI India

At junctions, pedestrian crossings provide designated places for people to cross. Median refuge areas help pedestrians to wait in a safe space while crossing the road. Ramps help provide universal accessibility.

EXISTING CONDITIONS

This existing conditions on site indicate active road edges with local vending shops attracting customers from all directions. Absence of a median and any refuge for pedestrians leads to chaotic crossing and increased conflict points at the junction.

PROPOSED CONDITION

To eliminate vehicle and pedestrian conflict while crossing at market area intersections, design elements such as median extensions, painted crossings, road markings, median refuges and bollards can be provided.

1.3 BARRIER FREE DESIGN

Designing inclusive streets is crucial for ensuring that all road users, regardless of age, ability, or mode of transport, can navigate urban spaces safely and comfortably. Inclusive street design promotes equity, allowing pedestrians, cyclists, persons with disabilities, and public transport users to access streets safely.

Key elements of an urban built environment, information systems, infrastructure developments and their internal services play an active role in shaping one's accessibility experience.

Missing out on even a small component can exclude several humans with special needs. Likewise, the presence of small and apt features can improve inclusion for many. This section details key design elements that can improve street accessibility for all users.

Location: Church St, Bengaluru

Image: Harmonised Guidelines & Standards for Universal Accessibility in India, NIUA

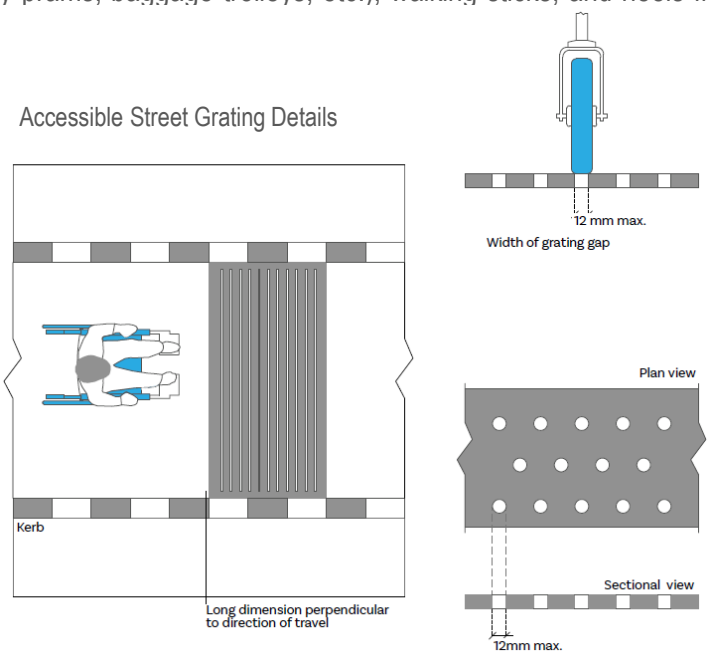
1.3.1 Universal Accessibility

1.3.1.1 Walkways

1. Minimum walkway widths shall be 1200 mm. However, for two-way traffic, it needs to be 2000 mm wide. In exceptional cases (such as around trees/poles etc.); the recommended clear width could be 1500 mm.
2. The walkway should not have a gradient exceeding 1:20. It also refers to cross slope.
3. For walkways greater than 60 m in length, resting spaces with street furniture shall be provided at every 30 m. Seating height should be between 450 mm-500 mm, have a backrest and hand rests at 700 mm height.
4. Covered walkways shall have a minimum clear height of 2200 mm.
5. Grab rails on both sides shall be provided along access routes or walking trails, wherever the land terrain is sloping or undulating. The grab rails in contrasting colours shall be fixed at two levels, ranging between 700 to 900 mm.
6. Walkways should be well-illuminated to ensure adequate visual contrast and unobstructed routes for all. Lighting fixtures not exceeding a height of 4 m from ground level should be provided. This would enhance accessibility for persons with low vision.
7. Level changes between 6 mm and 15 mm should be levelled off with a slope no greater than 1:2. Other details for level changes and gradient shall be as per the table given below

CHANGES IN VERTICAL RISE (MM)	GRADIENT NOT STEEPER THAN
0 to 15	1:2
more than 15 to 50	1:5
more than 50 to 200	1:10
Exceeding 200	1:12

8. Gaps in gratings and walking surfaces should not be more than 12 mm in width and be placed such that their length is perpendicular to the dominant direction of travel. This will help prevent wheels (of wheelchairs, baby prams, baggage trolleys, etc.), walking sticks, and heels from getting caught in the gaps.



Graphics: Harmonised Guidelines & Standards for Universal Accessibility in India, NIUA

1.3.1.2 Tactile Guiding Surface Indicators (TGSIs)

Tactile paving should be used on access routes to provide warning and guidance to people with visual difficulties. The need for TGSIs is critical and requires being constructed holistically with built environments. Partial and incorrect laying of TGSI's may cause inconveniences and may be hazardous for persons with visual impairments. Tactile ground surface indicators act as, and are interpreted as. landmarks.

There are two types of tactile ground surface indicators:
a. Warning indicators; and
b. Directional indicators.

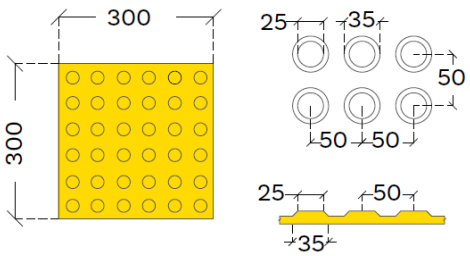


Fig a: Warning Indicators

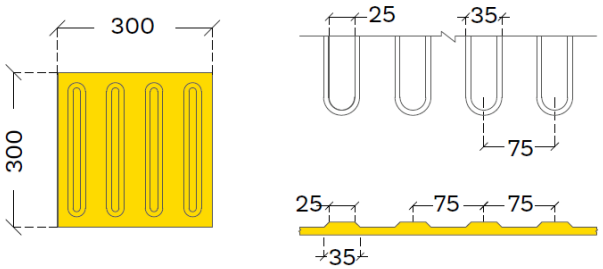


Fig b: Guiding Indicators

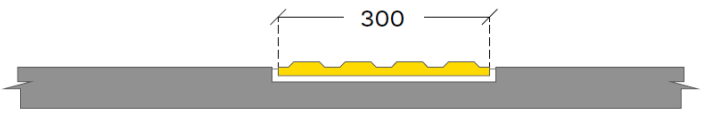


Fig c: Tactile Paver Section

The decision to apply tactile ground surface indicators will always have to be made considering the particular circumstances applicable at any given site. In making such decisions, consideration should be given to the orientation and mobility strategies and techniques adopted by people with visual impairments and the potential hazards and barriers existing at a given location.

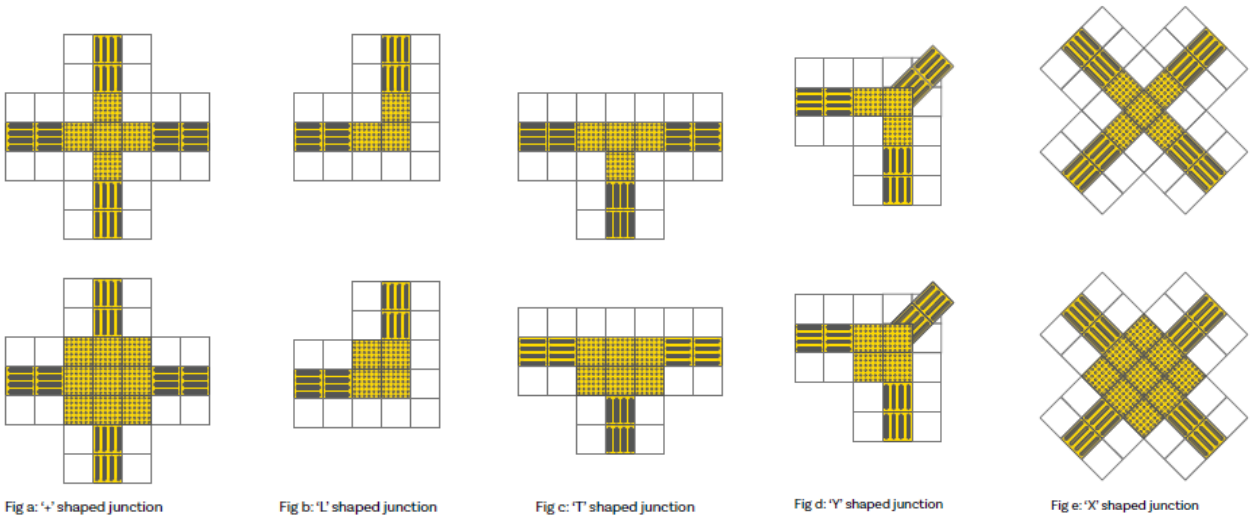


Fig a: '+' shaped junction | Fig b: 'L' shaped junction | Fig c: 'T' shaped junction | Fig d: 'Y' shaped junction | Fig e: 'X' shaped junction

Typical TGSI Junction Details

Graphics: Harmonised Guidelines & Standards for Universal Accessibility in India, NIUA

TGSI layout details around manhole covers on footpaths

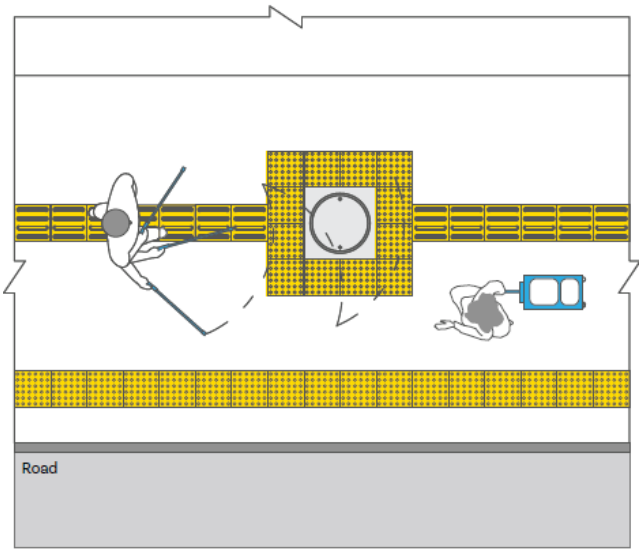


Fig a: TGSI around circular profile (Manhole cover)

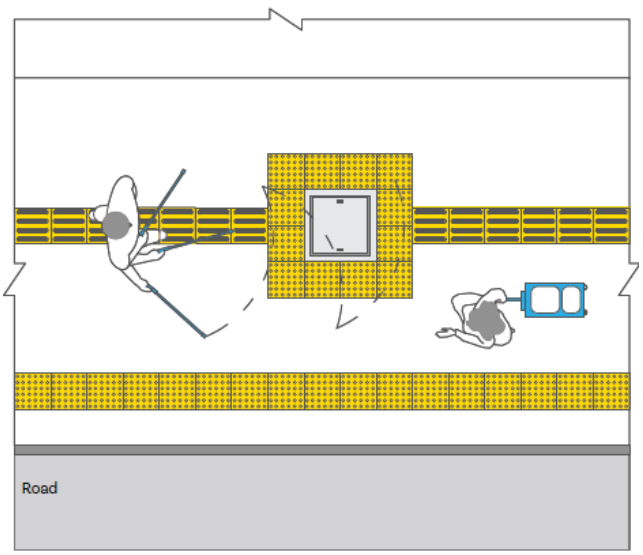


Fig b: TGSI around square profile (Manhole cover)

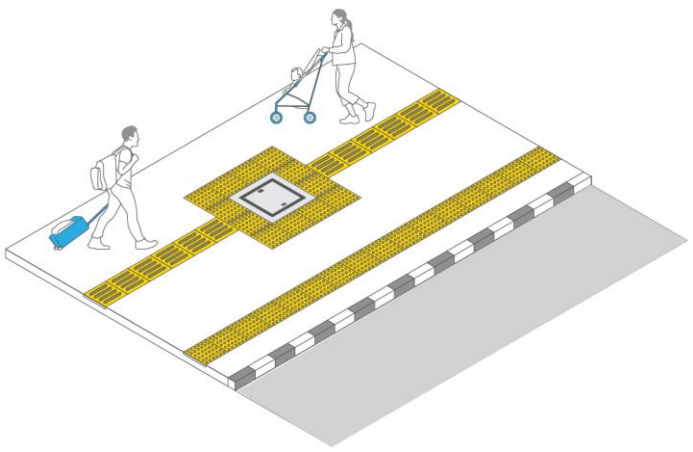
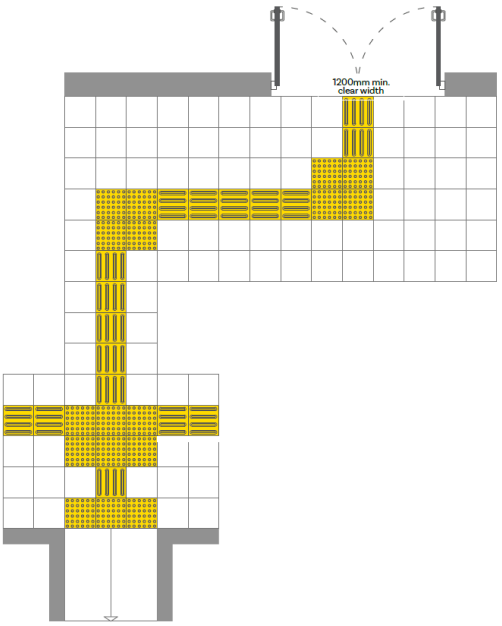


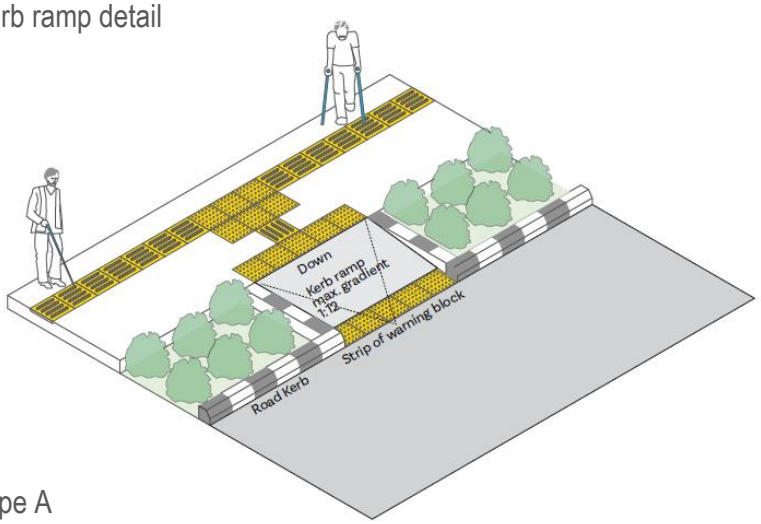
Fig c: TGSI around square profile (Manhole cover) (3D View)

Graphics: Harmonised Guidelines & Standards for Universal Accessibility in India, NIUA

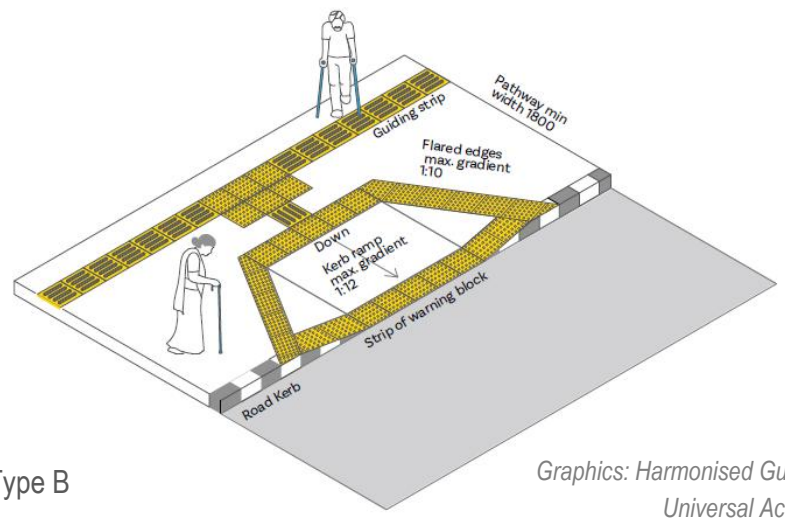
Configuration and layout of tactile guiding and warning tiles



Typical accessible kerb ramp detail



Type A

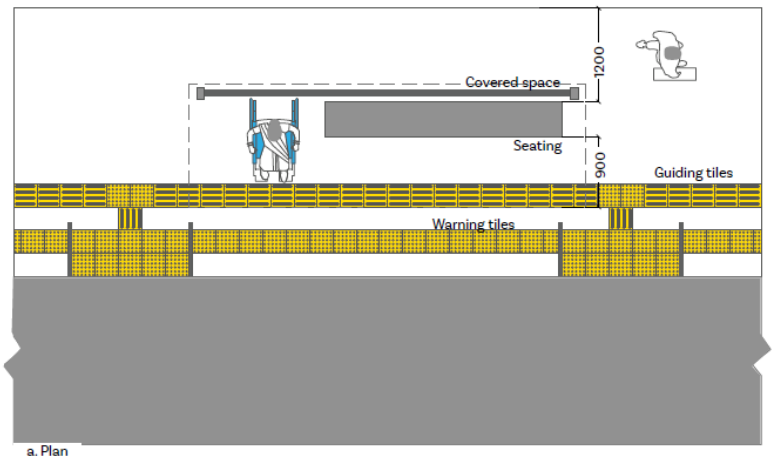


Type B

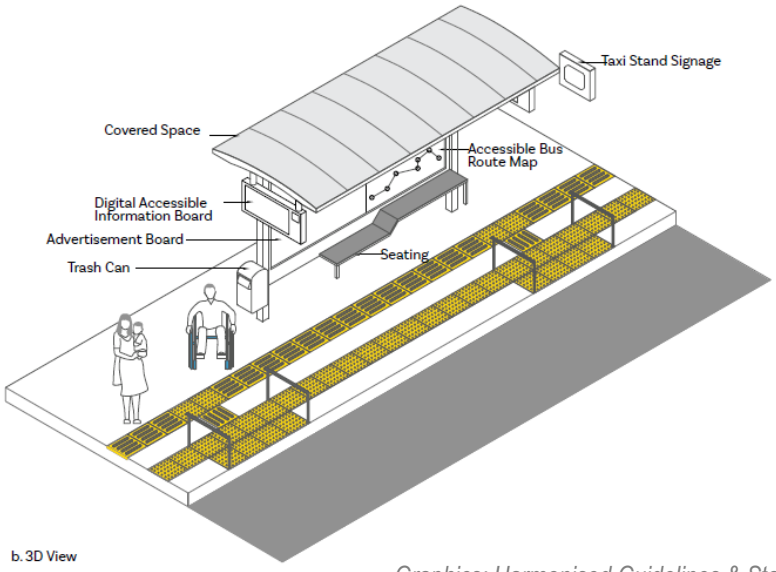
Graphics: Harmonised Guidelines & Standards for Universal Accessibility in India, NIUA

1.3.1.3 Bus Stops

- At least one accessible route should be provided from the alighting and boarding point of the bus stand to the walkway that leads to the accessible building entrance.
- Directional signs should be installed to direct persons with disabilities to an accessible entrance.
- TGSIs blocks should be provided along the accessible walkway from the bus stand to the building entrance to aid persons with visual impairments.
- The bus stand shall have minimum illumination level of 50 lux.
- The bus stand should be located nearest to an accessible entrance.
- Wherever a transfer must be made from a vehicular surface to a pedestrian surface, the driveway, pathway, or walkway should be blended to a common level or be ramped.
- A clear passageway with a minimum width of 1200 mm should be provided.
- Seats should be provided at the bus stand for people with ambulatory disabilities. These seats should be positioned so as not to impede the movement of wheelchair users.
- A shelter should be provided at the bus stand for protection against adverse weather conditions.
- If a bus stand is not at the same level as the walkway or pathway, it should have two separate ramps for boarding and alighting.
- Where there are kerbs between the access aisle and the vehicle pick-up space, it should have a kerb ramp. The minimum lighting should not be less than 80-100 lux.



a. Plan



b. 3D View

Bus Shelter Design

Graphics: Harmonised Guidelines & Standards for Universal Accessibility in India, NIUA

1.3.1.4 Parking

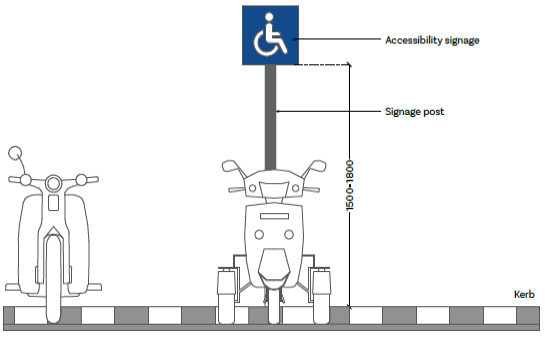
Accessible parking implies adequate parking for persons with diverse disabilities and vulnerable user groups like the elderly, etc. in built environments at all scales. Contextually, it shall include both parking for adapted scooters, tricycles, cars or any other personal vehicular system adopted by an individual with disability to reach the building premises.

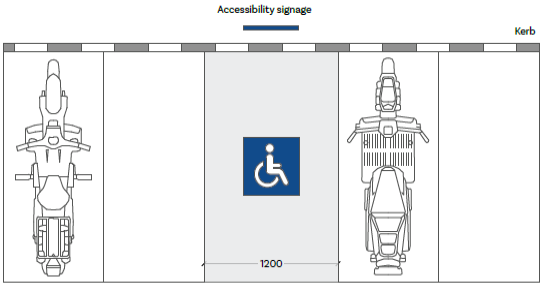
1. Reserved parking bays for adapted scooters, tricycles or other personal mobility devices (in the two-wheeler category) shall have a minimum bay size of 3000 mm x 2400 mm.
2. Accessible car parking bays shall have a minimum size of 5000 mm × 3600 mm, which is inclusive of 1200 mm wide side transfer zone. It shall also ensure adequate space for rear transfer of persons with disabilities specially wheelchair users.
3. When two accessible bays are adjoining each other, then the 1200 mm side transfer bay may be shared by the two parking bays. The transfer zones, both on the side and the rear, should have yellow or white cross-hatch road markings.
4. A minimum of one accessible parking bay shall be provided in all buildings. However, built forms with higher occupancy shall follow the norm as given in table below.
5. The parking bay should preferably be sheltered.
6. It shall have a firm, level surface without aeration slabs or soft grounds.

NUMBER OF VEHICLE PARKING UNITS	NUMBER OF ACCESSIBLE PARKING BAYS
For 50 parking lots (1-50)	1
Next 50 lots (51 – 100)	1
Every subsequent 100 lots or any part thereof	1

Accessible reserved parking bays

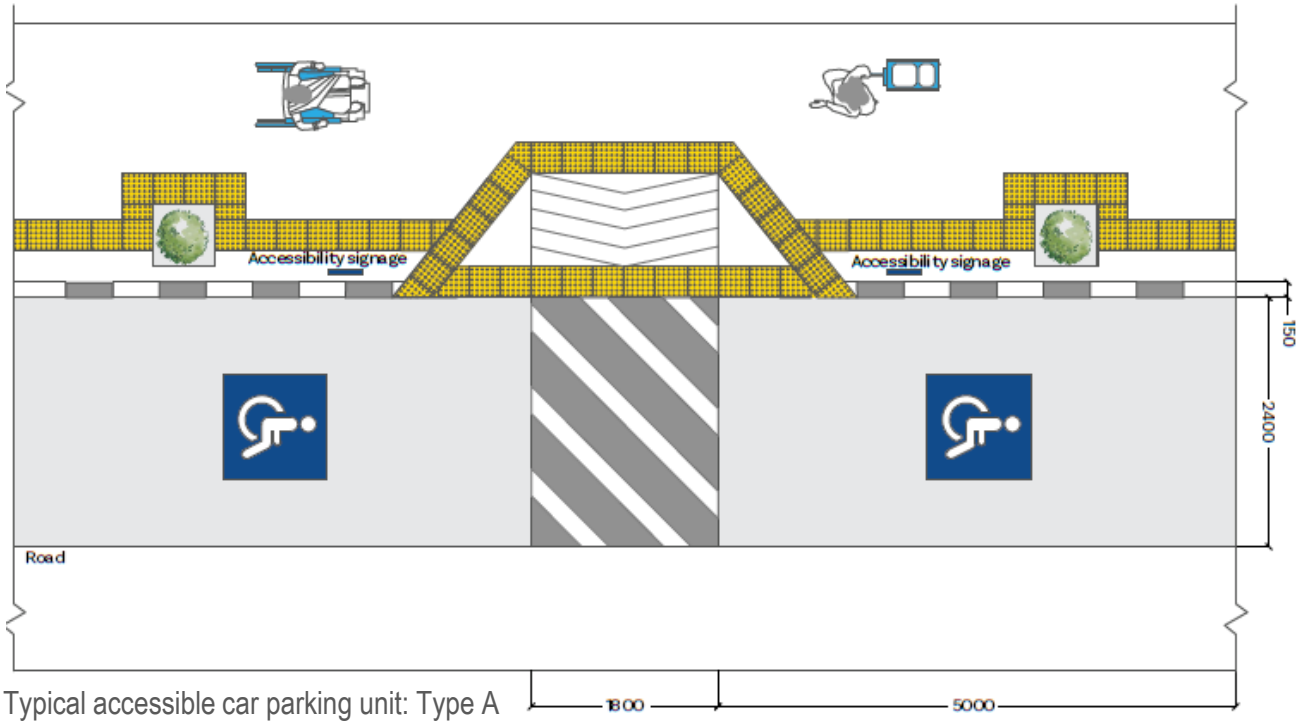
Parking space requirement for adapted scooter



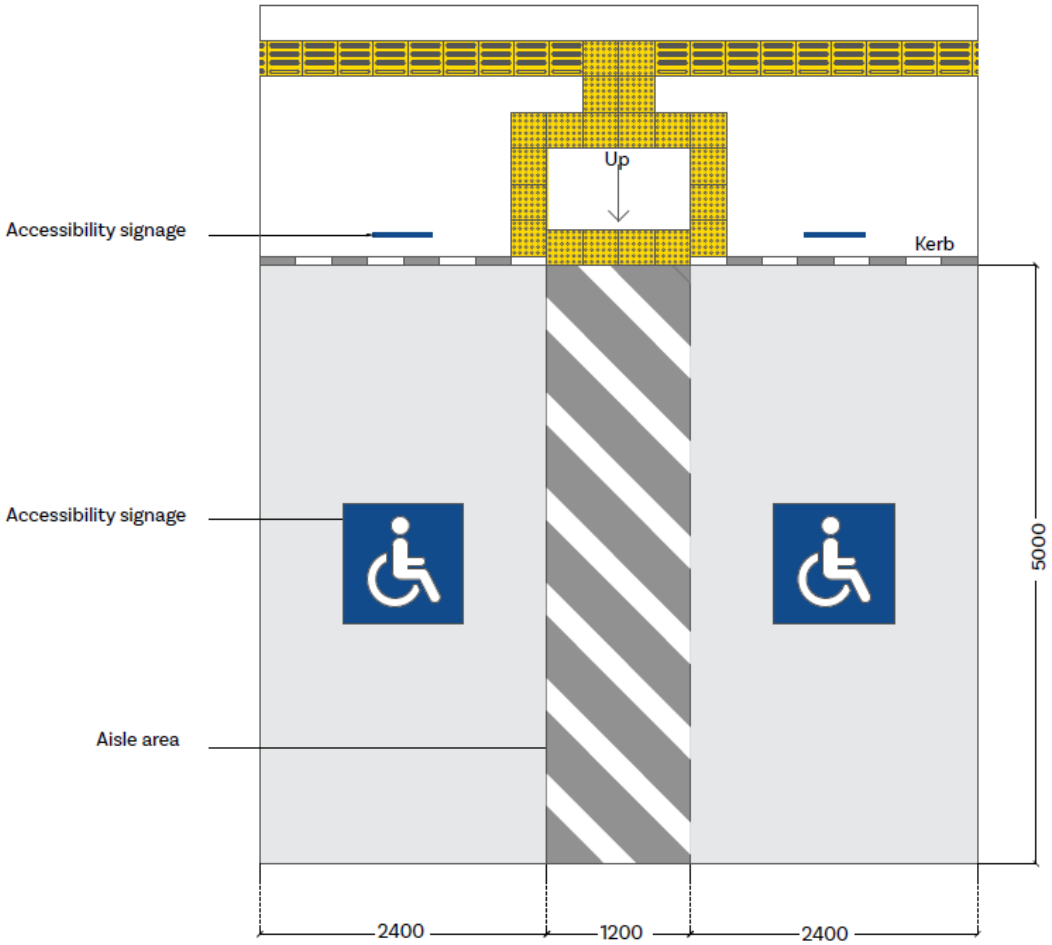


Vehicle parking (two wheeler parking/ adapted scooters)

Graphics: Harmonised Guidelines & Standards for Universal Accessibility in India, NIUA



Typical accessible car parking unit: Type A



Typical accessible car parking unit: Type B

Graphics: Harmonised Guidelines & Standards for Universal Accessibility in India, NIUA

1.3.2 Wayfinding

Signage enhances orientation and wayfinding for pedestrians, as well as vehicular users. It includes direction signs, traffic signs, location signs, and emergency/hazard warnings. The information should be distinct and legible, and their placement and material needs to work in synergy with other elements and amenities. Signage enhances both pedestrian and vehicular experiences and helps in wayfinding.

Depending on the purposes it serves, signage can be of following types:

- Directional
- Information
- Identification
- Instructive or Advisory
- Health, Safety & Emergency

Directional Signs

Directional signs provide wayfinding information to navigate in or around a physical environment. Arrow heads with travel routes at specific locations can aid wayfinding for diverse user groups.

Information Signs

Information signs help orient a person in a built environment by indicating specific locations within a space. This includes "You are Here" labels along with other building identification signs, such as zone identification in public buildings or transportation hubs.

Identification Signs

Identification signs are used to display necessary information to users, enabling them to identify a specific facility or location in built environments. For example, an accessible washroom facility can be identified by an accessibility sign outside the facility.

Instructive or Advisory Signs

Instructive or advisory signs may include signage that provide different instructions or related to human behaviour in built environments.

Health, Safety & Emergency Signs

Such signs include signage demarcating equipment for health emergencies or safety issues like fire, etc. This can provide a life-saving role within a built environment.

It shall be ensured that:

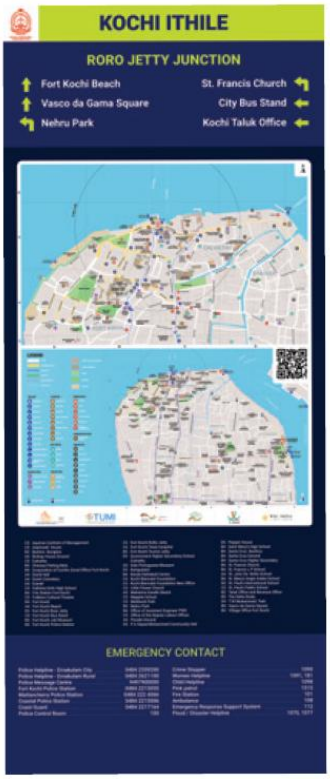
- Signages are lit at night and should be properly visible.
- They should be located at regular intervals with unified visual language.
- Signages must be clear, easy to read, and easy to understand.

PLANNING & DESIGN: BEST PRACTICES

- Multiple and related signs should be clustered around a single pole to avoid sign clutter.
- Signage should be ideally placed on shoulders or on parking spaces or in multi-utility zones. If placed on a footpath, they should not obstruct pedestrian flow or access to properties.
- Signage surfaces should be of a durable weather-resistant material and should prevent glare.
- The colour of signs should be in contrast to the surrounding surface, in order to avoid confusion for people with low vision and blindness (as per IRC standards).
- Design, colours, and fonts of signs should be in accordance with IRC 67 –2012.
- Vector signage should be used for wayfinding.
- Signage should be consistently maintained with regular painting and installations to ensure they are clearly readable.
- Regulatory and safety signage should be ideally placed along the edge zone or on the kerbside of a footpath so that they can be read easily by motorists and pedestrians.
- Signage should be uniform in design and patterns for seamless continuity while reading.
- Height of directional signage from the lowest edge should be minimum 2.1 m from the level of the footpath.

Wayfinding signs on the street. Location: JM Road, Pune.

Graphics: Harmonised Guidelines & Standards for Universal Accessibility in India, NIUA

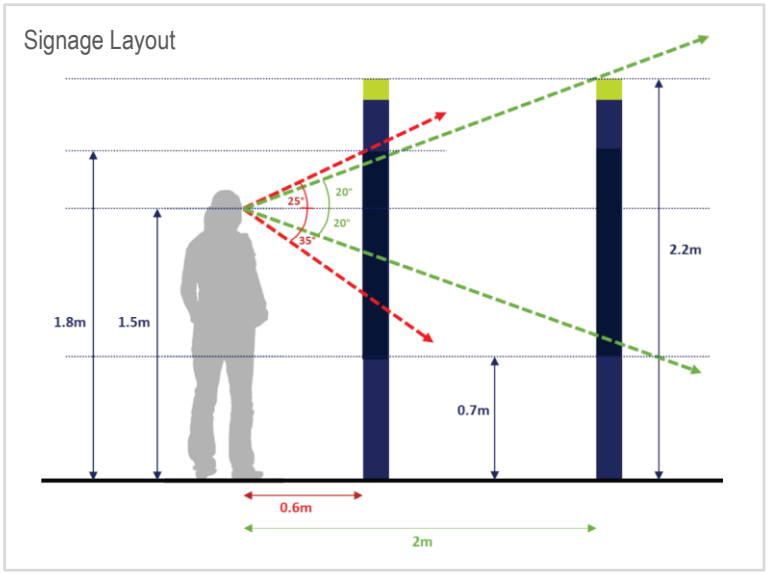


Physical Signage

Digital Signage

App and Website

Wayfinding signs on the street. Location: Kochi



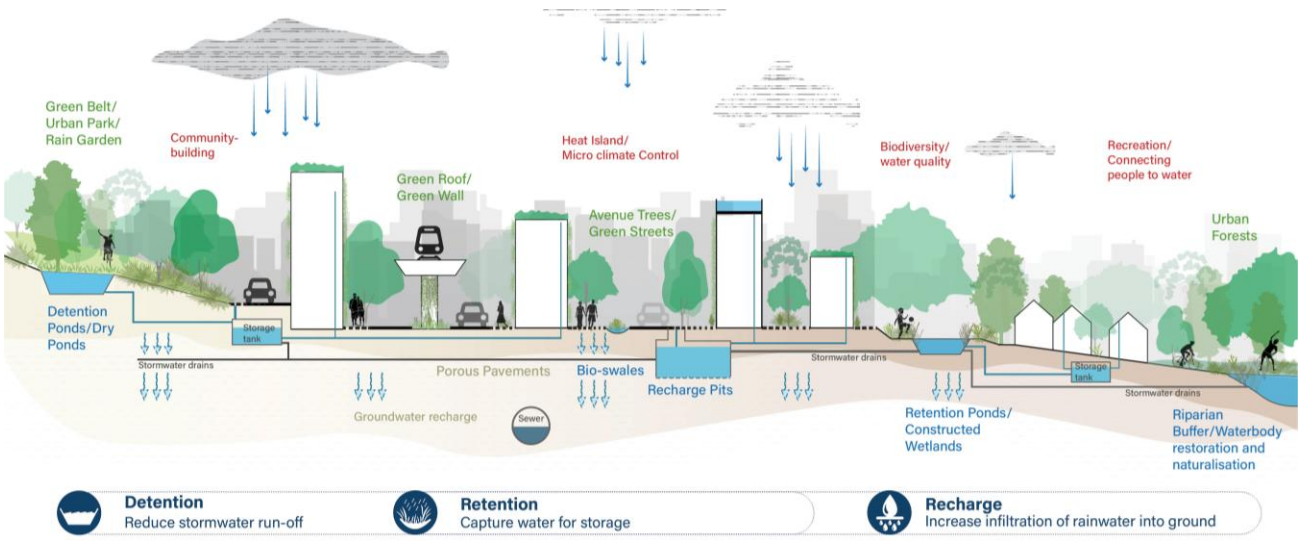
Graphics: Reimagining Fort Kochi, TUMI & WRI India

Braille cum Tactile Sign Boards and Route Maps

Graphics: Harmonised Guidelines & Standards for Universal Accessibility in India, NIUA

1.4 Blue-Green Infrastructure for Roads

Conceptual section of urban landscape which includes blue green infrastructure, streets, buildings and other resilience elements



Source: WRI India. Illustration created by Sindhuja Janakiraman

WRI INDIA
ROSS CENTER

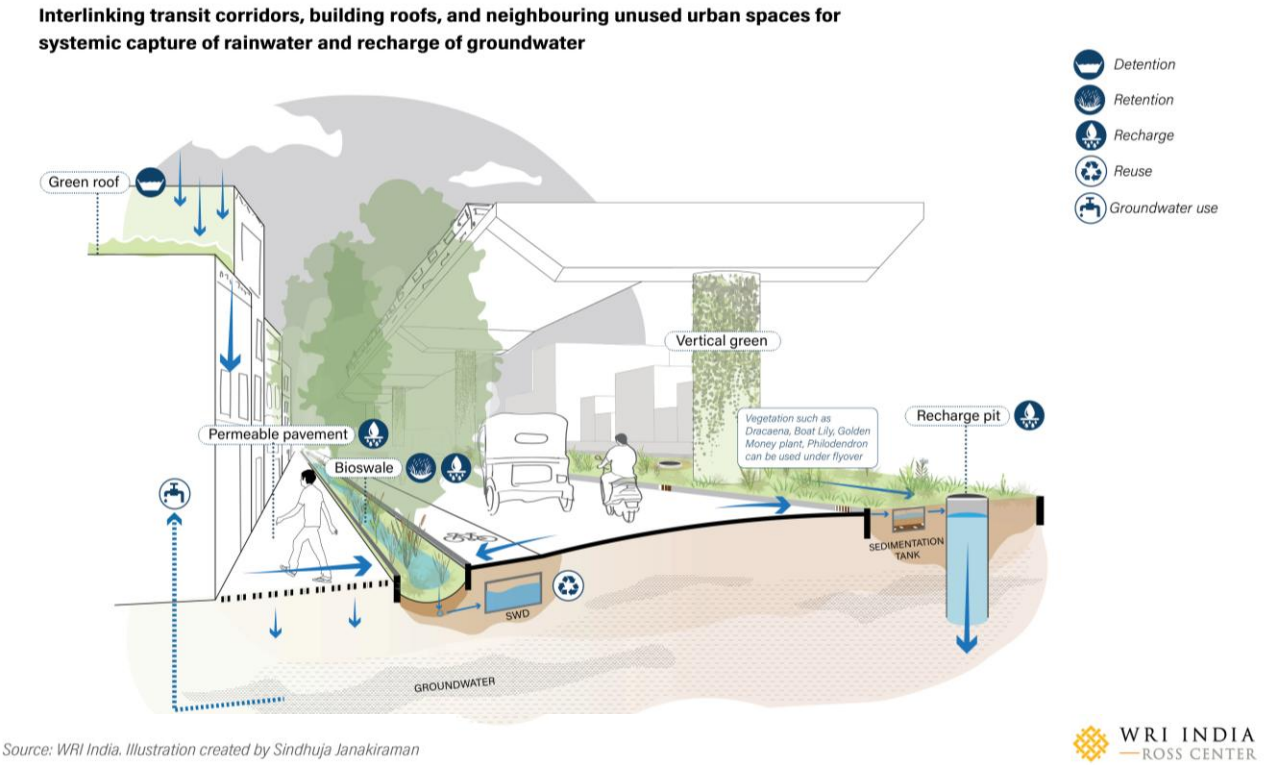
What is Blue Green Infrastructure?

Blue green infrastructure is natural infrastructure that includes green spaces (e.g. gardens, urban forests, green roofs, urban farms etc) as well as (blue) water networks such as lakes, rivers, streams, wetlands and other natural and constructed drainage channels (e.g. Rajakaluves).

The Importance of Blue-Green Infrastructure

Blue-green infrastructure (BGI) enhances urban ecological health by integrating natural elements into the built environment, counterbalancing the impacts of development. BGI filters pollutants, replenishes groundwater, mitigates the urban heat island effect, provides shade, and supports local biodiversity. Furthermore, BGI improves walkability and provides recreational spaces.
It can be incorporated into traffic calming, pedestrian infrastructure, and placemaking initiatives.

1.4.1 Blue Infrastructure



Resilient urban streets mitigate heat and flooding, crucial given Bengaluru's changing climate. Effective street and open space design incorporates flood mitigation, groundwater replenishment, and cooling through shading and permeable surfaces. Blue-green infrastructure (BGI) encompasses these elements, tailored to local conditions, land use, and available space. While prioritizing natural resource protection, BGI also enhances public spaces and walkability, benefiting physical and mental health.

Possibility of improvement at the Footpath at KSIT, Kanakapura Road

Neighbourhood Scale Low-Impact Development

The rendered photographs of Kanakapura Road near KSIT with blue-green strategies such as bioswales and tree cells implemented show how low-impact development (LID) can be implemented on a street scale to improve universal access, resiliency and create space for rest.

Existing Footpath at KSIT, Kanakapura Road

1.4.1.1 Storm Water Drainage

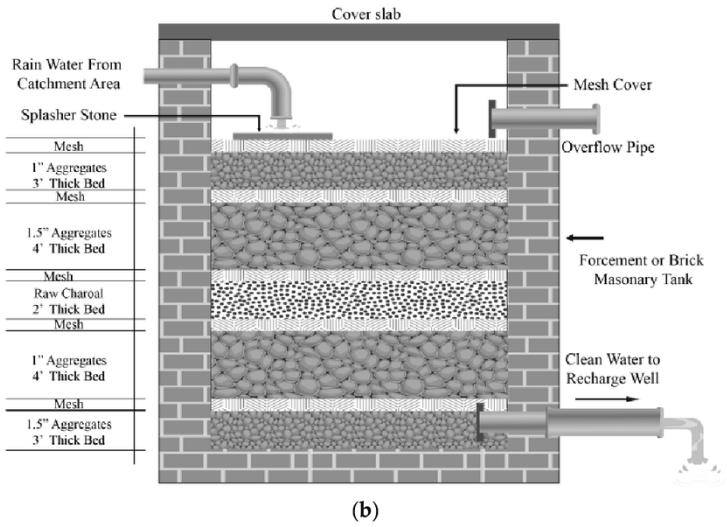
Effective stormwater drain design is crucial for managing water flow, replenishing groundwater, and minimizing environmental impact. It involves three key components:

1.Subsurface Piping: Pipes are preferred over box drains due to their reduced silting tendency and easier maintenance. Regular access points (chambers) are essential for inspection and periodic desilting, ideally performed section by section between chambers.

2.Groundwater Replenishment: Percolation pits within the chambers facilitate in-situ groundwater recharge. Vertical cylinders inside the pipes can further alleviate pressure on downstream drains and improve local water table levels.

3.Surface Water Interface: Effective street drain design and precise road cambering are vital for channeling surface water into the drain system. Silt chambers in street drains capture debris, preventing pipe blockage and simplifying maintenance, which can be integrated with street sweeping schedules.

Green buffers alongside roads and footpaths provide additional flow reduction and environmental benefits. This integrated approach ensures efficient stormwater management and sustainable water resource utilization.



Source: Assessing the Rainfall Water Harvesting Potential Using Geographical Information Systems

Vertical Recharge Chambers

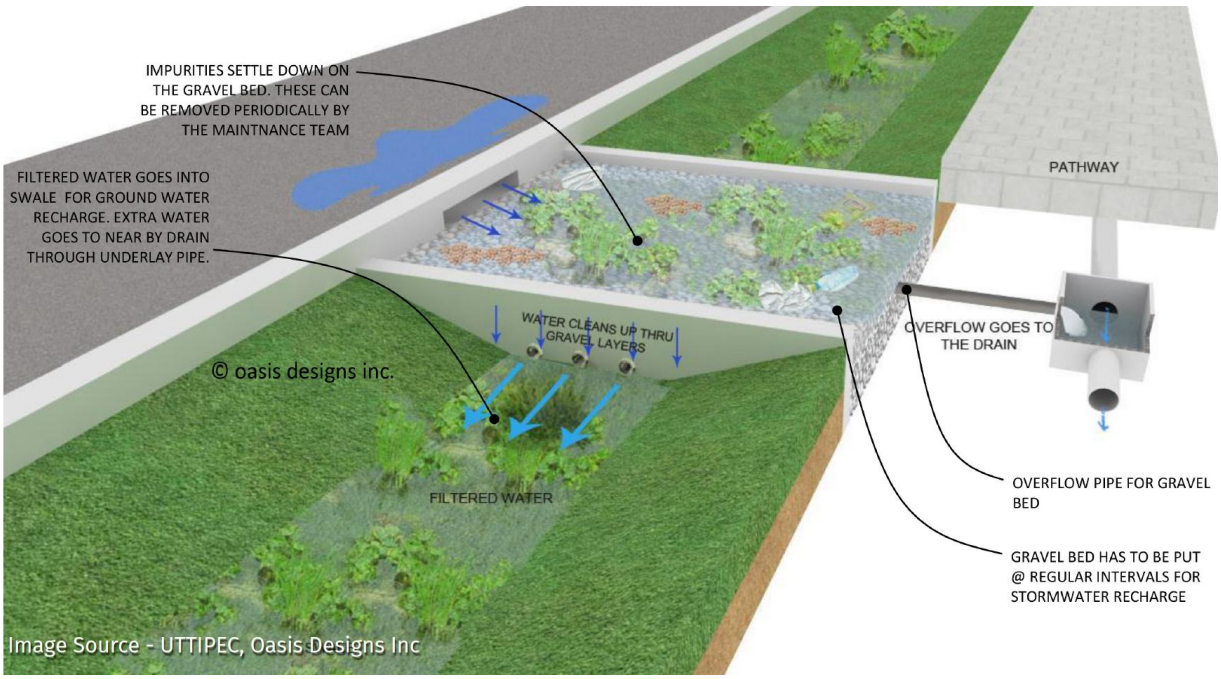
When placed regularly along storm water drains, these vertical chambers filter water and return the surrounding ground water table.

These vertical chambers intersect drain pipes, and provide a large vertical unit for storage and slow dissipation of water through layers of gravel and aggregate material. A 3' diameter, 20' deep chamber for example, can retain 4,000 litres of water.

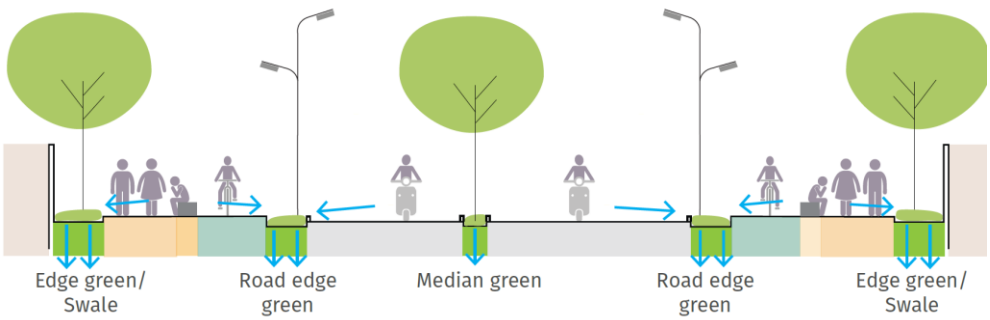
These chambers both purify water as well as lessen the pressure on storm water drains.

1.4.1.2 Storm Water Management

Bengaluru's intense sporadic rainfall heightened by the increased urbanization leads to rapid stormwater accumulation and frequent waterlogging, overwhelming conventional drainage systems. Therefore, relying solely on drains is insufficient. A comprehensive stormwater management strategy for Bengaluru must include not only conveyance (piped drainage) but also retention (slowing runoff), capture (harvesting), filtration (water treatment), and infiltration (groundwater recharge).



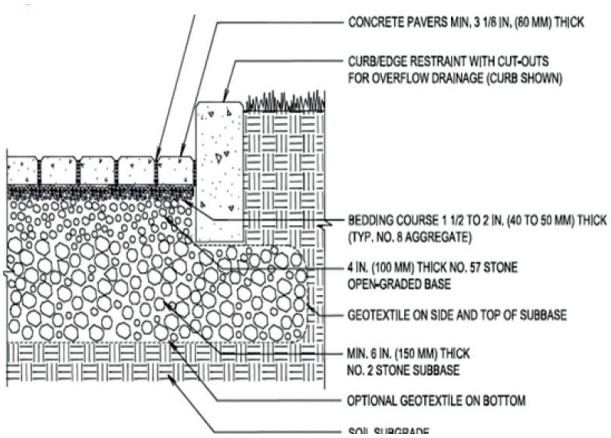
Green buffers such as in the image above allow excess storm water to slowly percolate and recharge the ground-water table. Vegetation can absorb some amount of water, while gravel removes impurities from the storm water before allowing it to penetrate into the ground. Excess water is piped into the drainage system.



Storm water can be captured at multiple spaces along the roadway to ease the burden on drainage systems.

Source: Street Design Guidelines, Delhi Urban Art Commission

1.4.1.3 Paver Materials



The usage of pavers can improve the permeability of roads. Street parking on carriageway edges (shoulders), footpaths, MUZs, buffer zones, shy-away zones, ward roads and conservancy lanes can all use pavers.

Pavers allow for greater percolation of stormwater into the ground, slow traffic due to higher friction and feedback, and provide safer walking conditions for pedestrians due to their textured surface.

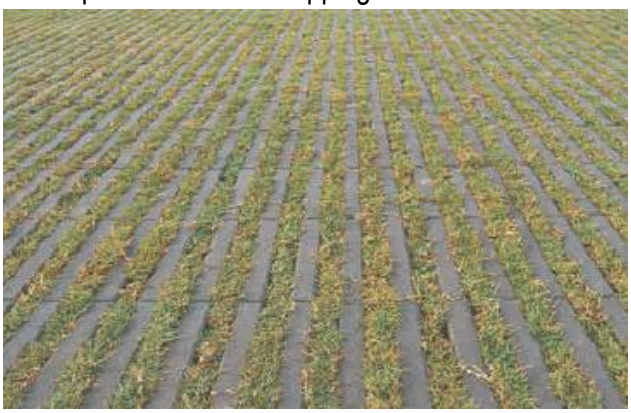
Different types of pavers provide different amounts of permeability and durability.

Cement Pavers: The most durable and long lasting paver, cement pavers are great for medium-traffic roadways. They however allow very little percolation of water into the ground.

Brick Permeable Pavers: Composed of hardened and kiln-fired clay or synthetic permeable materials, these pavers provide durability while still allowing for some percolation of water into the ground. Excellent for high-traffic footpaths and slow shopping streets.

Gravel + Pavers: Perfect for plazas, these pavers allow for greater permeability while still providing high levels of durability and functionality for high-footfall areas.

Source: Basant Betons



Grass + Pavers: Used in edge spaces of plazas and footpaths, the combination of vegetation and pavers allows for pedestrian use while also being extremely permeable. Additionally, the greenery helps reduce the heat island effect caused by excessive concretization.

1.4.2 Green Infrastructure

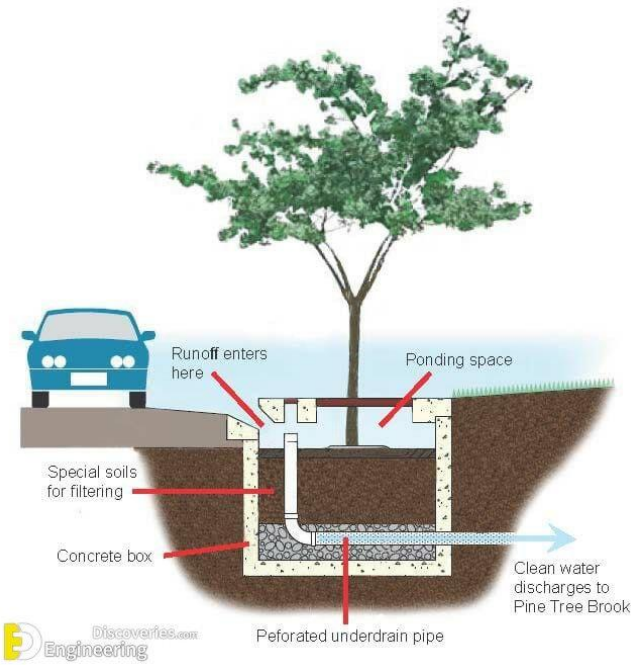
1.4.2.1 Roadside Tree Plantation and Protection

Roadside Tree Placement

Trees are vital to blue-green infrastructure, offering both heat and water resilience. They provide shade, mitigating urban heat island effects, and their root systems absorb excess stormwater, reducing runoff. Strategically planted trees along roadways create shaded public spaces with seating (e.g., *katte*s), promoting recreation and social interaction. Their foliage also acts as a natural air filter, capturing pollutants and improving air quality.

Optimal tree placement considers local conditions, including land use, footpath width, soil type, and existing vegetation. Integrating trees into green infrastructure elements like green buffers, bioswales, sunken plazas, and road shoulders maximizes their benefits. Permeable surfaces, such as pavers, grass, gravel, or tree grates, should be used at the tree-footpath interface to allow water infiltration and healthy root development.

Source: Draft Urban Tree Manual, WRI India



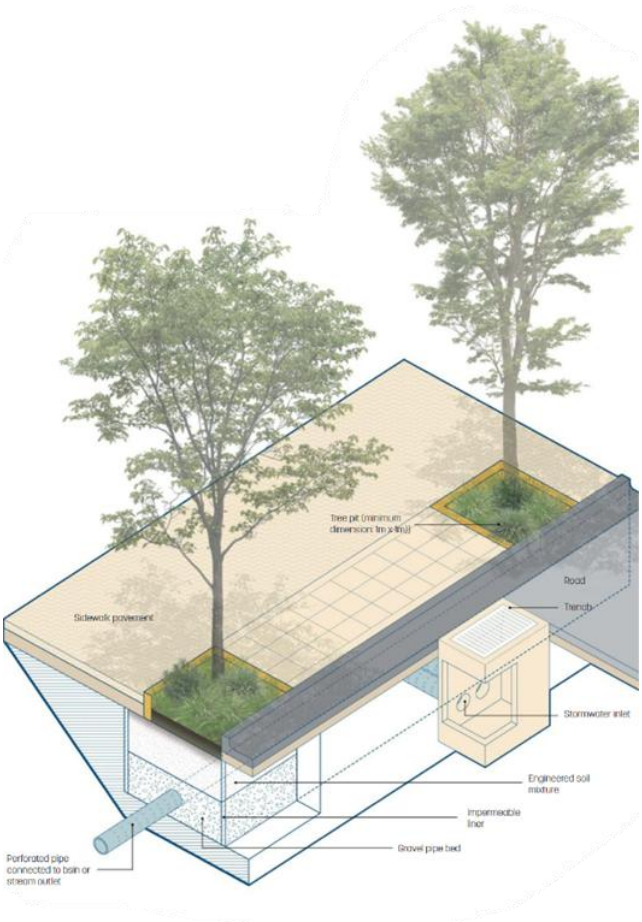
Source: Discoveries.com

Roadside Tree Grate

Roadside tree grates and adjoining infrastructure protect trees from vehicles, foot traffic and debris. Grates allow for water to nourish tree roots with stormwater from the footpath and roadway.

Grates are often attached to underground boxes that provide soil for roots to expand and to control the direction in which roots grow.

1.4.2.2 Resilient Street Typologies

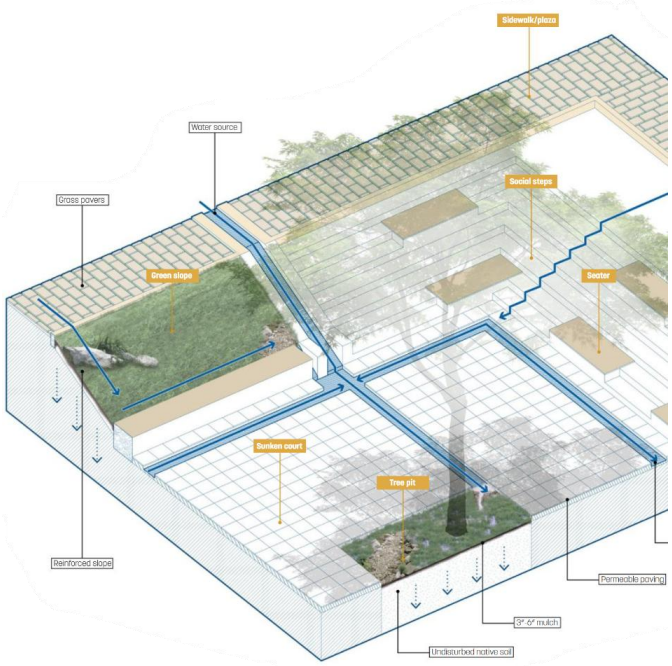


Green Buffers

These roadside bioswales direct stormwater from the footpath and carriageway into a permeable box composed of layers of gravel, soil and vegetation. The green buffer slows storm water, filters it and allows it to permeate into the ground. The greenery reduces the heat island effect of the surrounding paving while also serving as air-purifiers for immediate surroundings.

Green Kerb Cuts

Similar to green buffers, these junction corners are especially important for redirecting stormwater away from junctions. They additionally protect pedestrians from turning vehicles and serve to channel pedestrians into designated crosswalks rather than directly into the junction.



Sunken Plazas

These plazas function as public open spaces during normal conditions. However during storm conditions these depressed spaces serve as containers for excess storm water, preventing the flooding of roadways and buildings. The plazas can contain pedestrian infrastructure such as seating and play spaces, but importantly also contain green spaces for heat resilience and permeability. The lower elevation provides cool refuge during hot months, with trees in the plaza providing further shade.

Source: Sponge Handbook - Chennai

1.4.2.3 Recommended Native Trees for Road Median and Footpath Side Plantation

Note: The following list is not exhaustive, however all species are native and suitable for road medians and footpath edges

Sr. No.	Species Name	Common Name
1	Bambusa arundernacea	Big bamboo
2	Bixa Orellana	Achiote
3	Butea monosperma	Flame of the forests
4	Caesalpinia pulcherrima	Peacock tree
5	Callistemon lanceolatus	Bottle brush
6	Casuarina equisetifolia	She oak
7	Jacaranda mimosifolia	Jacaranda
8	Lagerstroemia flosreginae	Pride of India
9	Moringa oleifera	Drumstick
10	Pongamia pinnata	Karanja
11	Psidium guajava	Guava
12	Tabebuia aurea	Carribean Trump Tree
13	Thespesia populnea	Indian Tulip tree

Source: Urban Forestry Handbook for Bengaluru, B.Pac

1.4.2.4 Other List of Trees observed in Bengaluru

List of tree species in the Indian Institute of Science (K. Sankar Rao, 2009 and Field work)

Annexure IV

Sl. No	Botanical Name	Common Name	Family	Native	Location
1	*Acacia auriculiformis* Cunn. Ex Benth.	Australian wattle	Fabaceae	Australia	In front of SID
2	*Acacia catechu* (L. f.) Wild.	Black cutch tree	Fabaceae	India	Acacia-phoenix groove next to the swamp (P)
3	*Acacia chundra* (Roxb. Ex Rottl.)	red cutch	Fabaceae	India	Airstrip
4	*Acacia leucophloea* (Roxb.) Wild.	White-barked acacia	Fabaceae	Indomalayan region	Next to CEDT, Airstrip
5	*Acacia nilotica* (L.) Del. Subsp. Indica (Benth.) Brenan	Babul acacia	Fabaceae	India	Vijnanapura campus
6	*Adenanthera pavonina* L.	Coral seed tree	Fabaceae	China, Malaysia	In front of Centtral office-next to Tata statue
7	*Aegle marmelos* (L.) Corr. Serr.	Bael	Rutaceae	India	Main Guest House
8	*Ailanthus triphysa* (Dennst.) Alston	White palle	Simaroubaceae	India, Sri Lanka, Southeasr Asia, Australia.	Next to SSCU among Ficus pandurata
9	*Albizia lebbeck* (L.) Benth.	East indian walnut	Fabaceae	Asia	In front of CST and at several other locations on the campus.
10	*Albizia odoratissima* (L.f.) Benth.	Blacksiris	Fabaceae	Tropical Asia	Main Guest House
11	*Aleurites moluccana* (L.) Wild.	Candle-nut tree	Euphorbiaceae	Malaysia	In front of JNCASR President's Office
12	Alstonia macrophylla Wall. Ex DC.	Batino	Apocynaceae	Sri Lanka	Professor's quarters area
13	*Alstonia scholaris* (L.) R. Br.	Scholar tree	Apocynaceae	India	Next to Biochemistry Department
14	*Anacardium occidentale* L.	Cashew	Anacardiaceae	Northeastern Brazil	Airstrip area
15	*Annona cherimola* Mill.	Cherimoya	Annonaceae	Peru, Ecuador	Nursery
16	*Annona reticulata* L.	Bullock's heart	Annonaceae	Neotropics	Nursery
17	*Annona squamosa* L.	Custard apple	Annonaceae	West Indies	Vijnanapura campus
18	*Aphanamixis polystachya* (Wall.)	Pithraj tree	Meliaceae	Tropical Asia	Next to C mess
19	*Artocarpus altitilis* (Park.) Fosb.	Bread fruit	Moraceae	Malay Peninsula	Staff quarters
20	*Artocarpus heterophyllus* Lam.	Jack fruit	Moraceae	India	Near Faculty Club
21	*Artocarpus hirsutus* Lam.	Wild jack	Moraceae	Tropical Asia	Telecom Bureau premises
22	*Averrhoa carambola* L.	Star fruit	Oxalidaceae	Sri Lanka	One readily accessible trees is in the nursery
23	*Azadirachta indica* A. Juss.	Neem tree	Meliaceae	India	Airstrip and staff quarters
24	*Barringtonia acutangula* (L.)	Indian Oak	Lecythidaceae	Southeast Asia, N. Australia	In front of JNCASR President's Office
25	*Barringtonia asiatica* (L.) Kurz.	Fish poison tree	Lecythidaceae	South Pacific Islands	Archives Cell premises
26	*Bauhinia racemosa* Lam.	Indian kanchan	Fabaceae	Tropics of both hemispheres	Next to Lecture Hall Complex (T)
27	*Bauhinia blakeana* Dunn.	Hong kong orchid tree	Fabaceae	Hong Kong	Main Quadrangle
28	*Bauhinia galpinii* N.E. Br.	Pride of the cape	Fabaceae	South Africa	Nursery
29	*Bauhinia tomentosa* L.	Brazilian orchid tree	Fabaceae	Tropical Asia, Africa	CST area
30	*Bauhinia forficata* Link	Burmese silk orchid	Fabaceae	Brazil, Peru	Jubilee Garden
31	*Bauhinia purpurea* L.	Butterfly tree	Fabaceae	India, Burma, Vietnam	Main Quadrangle and other locations
32	*Bauhinia variegata* L.	Mountain ebony	Fabaceae	India, China	Next to Kabini canteen
33	*Bauhinia variegata* L. var. candida Voigt.	White bauhinia	Fabaceae	China	Nursery
34	*Bauhinia purpurata* (Vieill.)	Purple orchid tree	Fabaceae	Asian tropics	Park in front of Airstrip
35	*Bolusanthus speciosus* (Bolus)	Tree wisteria	Fabaceae	Mozambique	Next to Electrical Engineering
36	*Bombax malabaricum* DC.	Red Silk-cotton tree	Bombacaceae	India	Next to Centre for High Energy Physics
37	*Brassaia actinophylla* Endl. Var. capitata Clarke	Queensland umbrella tree	Araliaceae	Australia	MBU car parking
38	*Broussonetia papyrifera* Vent.	Paper mulberry	Moraceae	East Asia	Behind CES
39	*Broussonetia luzonica* Bureau	Limba bao	Moraceae	Philippines	Miniforest
40	*Brownea coccinea* Jacq.	West indian Mountain rose	Fabaceae	Tropical America	NIAS
41	*Butea monosperma* (Lam.) Taub.	Flame of the forest	Fabaceae	India	Behind Main Guest House
42	*Caesalpinia ferrea* Mart. Ex Tul.	Brazilian ironwood	Fabaceae	Eastern Brazil	TMC Club
43	*Callistemon viminalis* (Soland. Ex Gaertn.) G. Don	Drooping bottle-brush	Myrtaceae	Australia	By the side of Material Research Centre
44	*Calophyllum inophyllum* L.	Alexandran laurel	Clusiacea	Mozambique, Tropical Asia	Biochemistry Department quadrangle
45	*Cananga odorata* (Lam.) Hook.f. & Thoms.	Scented Ylang-Ylang	Annonaceae	Indo-malaysian	Student Hostels area
46	*Cassia fistula* L.	Indian laburnum	Fabaceae	India, China, Southeast Asia	Behind Tata Memorial Library
47	*Cassia grandis* L.f	Brazilian cassia	Fabaceae	Tropical America	Student Hostels area
48	*Cassia javanica* L.	Java cassia	Fabaceae	Southeast Asia	Next to Central Office building
49	*Cassia moschata* Kunth	Bronze shower tree	Fabaceae	Panama, Columbia	Next to Central Offica Building and Nursery
50	*Cassia roxburghii* DC.	Red cassia	Fabaceae	Sri Lanka	Behind Central Office building
51	*Cassia spectabilis* DC.	Popcorn bush cedar	Fabaceae	Tropical Southeast Asia	Along the road to Main Guest House
52	*Cassine paniculata* (Wight & Arn.)	Indian cassine	Celastraceae	India	Main Guest House
53	*Castanospermum australe* Cunn. & Fraser	Australian chestnut	Fabaceae	Australia	Behind old Faculty Club
54	*Casuarina equisetifolia* L.	She-oak	Casuarinaceae	Malaysia, S. Asia, Australia	Next to JN Tata Auditorium
55	*Cedrela odorata* L.	Spanish cedar	Meliaceae	West Indies, Central & South America	Old Faculty Club
56	*Ceiba pentandra* (L.) Gaertn.	Kapok tree	Bombacaceae	South & Central America	Next to D gate
57	*Ceiba speciosa* (A. St. Hil.) Ravenna	Floss-silk tree	Bombacaceae	Brazil, Argentina	In front of Central Office building
58	*Centrolobium microchaete* (Mart. Ex Benth.)	Canary wood	Fabaceae	South America	Krithika hostel
59	*Chukrasia tabularis* A. Juss.	Indian redwood	Meliaceae	India, SE Asia	Near CES
60	*Cinnamomum verum* J.S. Presl	True cinnamon tree	Lauraceae	India, Sri Lanka	Medicinal and Aromatic Plants Garden
61	*Citharexylum fruticosum* L.	Fiddle wood	Verbenaceae	Caribbean Territories	Director's Bungalow premises
62	*Cirtus grandis* (L.) Osbeck	Pomelo	Rutaceae	Southeast Asia	Next to Hoysala Guest House
63	*Clusia rosea* Jacq.	Autograph tree	Clusiacea	Tropical America	Behind Central Office building
64	*Cochlospermum religiosum* (L.)	Yellow silk cotton tree	Cochlospermaceae	Tropical Asia	Main Guest House, Main Quadrangle
65	*Colvillea racemosa* Boj.	Colville's glory	Fabaceae	Madagascar	Main Quadrangle
66	*Cordia lutea* Lam.	Yellow cordia	Boraginaceae	Peru, Ecuador	Nursery
67	*Cordia wallichii* G. Don	Indian cherry	Boraginaceae	West Asia	MBU car parking
68	*Couroupita guianensis* Abul.	Cannon-ball tree	Lecythidaceae	French Guiana	JNCASR Office
69	*Crescentia cujete* L.	Calabash tree	Bignoniaceae	West Indies, Tropical America	Main Quadrangle
70	*Dalbergia latifolia* Roxb.	East indian rosewood	Fabaceae	India	MCB Department, Next to Faculty Club
71	*Dalbergia sissoo* Roxb.	North Indian rosewood	Fabaceae	India	Main Quadrangle
72	*Delonix regia* (Bojer ex Hook.) Raf.	Gulmohur	Fabaceae	Madagascar	Gulmohur Marg
73	*Duadanga grandiflora* (Roxb. Ex DC.) Walp.	Lampatti	Sonneratiaceae	Cambodia, E.India, Laos	Miniforest
74	*Dillenia indica* L.	Elephant apple	Dilleniaceae	India	Next to MBU Parking
75	*Diospyros cordifolia* Roxb.	Mountain persimmon	Ebenaceae	India, Sri Lanka, Malaysia, Australia	Main Quadrangle
76	*Diospyros ebenum* Koenig.	Ceylon ebony	Ebenaceae	India	Main Guest House
77	*Diospyros melanoxylon* Roxb.	Bale	Ebenaceae	India	Main Guest House
78	*Drypetes roxburghii* (Wall.) Hurus	Indian amulet tree	Euphorbiaceae	India	Main Guest House
79	*Elaeocarpus grandis* F. Muell.	Blue-marble tree	Elaeocarpaceae	Australia	Director's Bungalow and Main Guest House
80	*Emblica officinalis* Gaertn.	Indian gooseberry	Euphorbiaceae	Southeast Asia	Nursery
81	*Enterolobium contortisiliqum* (Vell.)	Pacara earpod	Fabaceae	Brazil, Bolivia, Paraguay, Argentina	Student Council
82	*Eriobotrya japonica* (Thunb.) Lindley	Loquat	Rosaceae	China	Director's Bungalow and Duplex Quarters
83	*Erythrina umbrosa* Kunth	Crimson Mortel tree	Fabaceae	Neotropics, India	Swamp (P)
84	*Erythrina suberosa* Roxb.	Corky coral tree	Fabaceae	India, SE Asia	Airstrip
85	*Erythina standleyana* Krukoff	Tiger wood	Fabaceae	Central America	C mess area
86	*Erythroxylum monogynum* Roxb.	Bastard sandal of India	Erythroxylaceae	India	Semi-wild area (J)
87	*Eucalyptus tereticornis* Sm.	Forest red gum	Myrtaceae	Australia	Nilgiri marg
88	*Eugenia uniflora* L.	Surinam cherry	Myrtaceae	Surinam, Guyana	Nursery
89	*Filicium decipiens* (Wt. & Arn.)	Fern leaf tree	Sapindaceae	India	Next to IPC
90	*Ficus auriculata* Lour.	Elephant year fig tree	Moraceae	Southeast Asia	Rohini hostel
91	*Ficus benghalensis* L.	Banyan tree	Moraceae	India	Behind Aerospace Engineering
92	*Ficus benjamina* L.	Benjamin fig	Moraceae	India, Malaya	Main Quadrangke, Director's Bunglow
93	*Ficus drupacea* var. pubescens (Roth) Corner	Mysore fig	Moraceae	India	Area next to Jubilee Garden
94	*Ficus elastica* Roxb. Ex Hornem.	India rubee tree	Moraceae	Southeast Asia	Next to Archives Cell
95	*Ficus pandurata* Hance	Fiddle leaf fig	Moraceae	Tropical West Africa	Next to SSCU
96	*Ficus infectoria* sensu Roxb. - Type I	Indian White fig	Moraceae	India, Nepal, Sri Lanka	Main Guest House

Source: Trees of Bengaluru, ENVIS Technical Report 75, ENVIS, Centre for Ecological Sciences, IISc

1.4.2.4 Other List of Trees observed in Bengaluru

97	*Ficus infectoria* sensu Roxb.-Type II	Pakur	Moraceae	India	Next to SSCU
98	*Ficus virens* Aiton (Ficus infectoria sensu Roxb. -Type III)	Spotted White Fig	Moraceae	India, SE Asia	Vijnanapura campus
99	*Ficus racemosa* L.	Cluster Fig	Moraceae	India	Department of Instrumentation
100	*Ficus religiosa* L.	Peepal tree	Moraceae	India, Burma	Next to MRC
101	*Firmiana colorata* (Roxb.) R. Br.	Coloured Sterculia	Sterculiaceae	India	Materials Engineering
102	*Flacouratia inermis* Roxb.	Batoko plum	Flacouratiaceae	Philippines	Next to JN Tata Auditorium
103	*Calamus prasinus* Lak. & Renuka	Ontibetha	Arecaceae	India	Miniforest
104	*Caryota mitis* Lour.	Clustered Fish-tail palm	Arecaceae	Tropical Asia	By the side of Central Office building
105	*Caryota urens* L.	Fish-tail palm	Arecaceae	Sri Lanka, India	In front of Central Office building
106	*Cocos nucifera* L.	Coconut palm	Arecaceae	Indo-Pacific	Nursery
107	*Cyrtostachys renda* Blume	Red sealing wax palm	Arecaceae	Malaysia, Borneo	JNCASR city office premises
108	*Dypsis lutescens* (Wendl.) Beentze & Dransfield	Golden cane palm	Arecaceae	Madagascar	At several locations, in front of ECE
109	*Hydristele wendlandiana* (C. Moore & F. Muell.) H. Wendl. & Drude	Florence fall palm	Arecaceae	Tropical Australia	Main Guest House
110	*Livistona chinensis* (Jacq.) R. Br. Ex Mart.	Chinese fan palm	Arecaceae	South China	In front of Electrical Engineering Department
111	*Livistona rotundifolia* (Lam.) Mart.	Roundleaf fan palm	Arecaceae	Southeast asia	Behind SID building
112	*Phoenix roebelinii* O'Brien	Pigmy date palm	Arecaceae	Laos, Thailand, Possibly Myanmar	Park between Lecture hall complex and admissions office
113	*Phoenix rupicola* T. Anders	Dwarf date palm	Arecaceae	India, Bhutan	In front of Main Guest House
114	*Rhapis excelsa* Henry	Lady palm	Arecaceae	South China	Registrar's Quarters
115	*Phoenix sylvestris* (L.) Roxb.	Wild date palm	Arecaceae	India	Swimming pool area
116	*Pritchardia pacifica* Seem. & H. Wendl.	Fiji fan palm	Arecaceae	Tonga, Fiji Islands	Instrumentation premises
117	*Ptychosperma macarthuri* Nichols	Macarthur palm	Arecaceae	New Guinea, Australia	Next to Automation Department
118	*Roystonea regia* (H.B.K) O. F. Cook	Cuban royal palm	Arecaceae	Cuba	Next to Lecture Hall Complex (T)
119	*Syagrus romanzoffianum* (Cham.)	Glassman	Arecaceae	Brazil	Next to Mathematics
120	*Thrinax parviflora* Sw.	Jamaican Thatch palm	Arecaceae	Jamaica	Biochemistry Quadrangle, Electrical Engineering
121	*Garcinia indica* (Thouars) Choisy	Coccum	Clusiaceae	India	Miniforest
122	*Gliricidia sepium* (Jacq.) Kunth ex Walp.	Quickstick	Fabaceae	South America	Main Quadrangle
123	*Gmelina arborea* Roxb.	White teak	Verbenaceae	India	Next to water Tunnel Lab
124	*Grevillea robusta* Cunn. Ex R. Br.	Silver oak	Proteaceace	Australia	Silver Oak Marg
125	*Grewia asiatica* sensu Masters	Phalsa	Tiliaceae	South Asia	Next to Mechanical Engineering
126	*Guazuma ulmifolia* Lam.	Honey-fruit tree	Sterculiaceae	Central America	Next to MBU
127	*Heritiera littoralis* Dyrand.	Looking glass tree	Sterculiaceae	Old world tropics	Near C mess
128	*Hibiscus tiliaceus* L.	Yellow mallow Tree	Malvaceae	Tropical Asia	Main Guest House, Gymkhana
129	*Jacaranda acutifolia* Humb. & Bonpl.	Jacaranda	Bignoniaceae	South America	Main Quadrangle
130	*Joannesia princeps* Vell.	Araranut Tree	Euphorbiaceae	Coastal Brazil	Behind former faculty club
131	*Khaya senegalensis* (Desr.) A. Juss.	African mahogany	Meliaceae	Central America	On the way to NIAS
132	*Kigelia africana* (Lam.) Benth.	African sausage tree	Bignoniaceae	Tropical West Africa	Jubilee Garden
133	*Lagerstroemia speciosa* (L.) Pers.	Pride of india	Lythraceae	India	Main Quadrangle
134	*Lepisanthes tetraphylla* (Vahl) Radlk.	Wild aphania	Sapindaceae	Tropical Africa. S. & SE Asia, Australia	Main Quadrangle
135	*Leucaena latisiliqua* (L.) Gillis	Subabool	Fabaceae	Central America	Semi-wild area
136	*Limonia acidissima* L.	Wood apple	Rutaceae	India	Main Quadrangle
137	*Litchi chinensis* Sonn.	Litchi	Sapindaceae	South China	Nursery
138	*Lonchocarpus minimiflorus* J.D. Smith	Chapleno	Fabaceae	Trinidad, Tobago	By the side of JN Tata Library
139	*Madhuca indica* J. Gmelin	Butter tree	Sapotaceae	India	One specimen is in front of Tata Book House and another next to Science Informatio Centre
140	*Magnolia grandiflora* L.	Lily tree	Magnoliaceae	Tropical America	On either side of Tata Statue
141	*Majidea zanguebarica* Oliv.	Velvet-seed tree	Sapindaceae	Tropical Kenya	Main Quadrangle
142	*Malpighia glabra* L.	Barbados cherry	Malpighiaceae	Tropical America	NIAS premises
143	*Mangifera indica* L.	Mango tree	Anacardiaceae	India	Nursery
144	*Manihot glaziovii* Muell. -arg.	Ceara rubber tree	Euphorbiaceae	Central America	Behind Main Guest House
145	*Manilkara zapota* (L.) P. Royen	Sapodilla	Sapotaceae	Central America	Main Guest House
146	*Markhamia lutea* (Benth.) K.Schum.	Siala	Bignoniaceae	Tropical Africa	On the way to D gate
147	*Melaleuca bracteate* F. Muell.	River tea tree	Myrtaceae	Australia	One specimen is in Nursery
148	*Melaleuca leucodendron* L.	Punk tree	Myrtaceae	Australia	Next to Central Office building
149	*Melia azedarach* L.	Persian Lilac	Meliaceae	Australia	CST
150	*Melia dubia* Cav.	China berry	Meliaceae	India, Tropical Asia, Angola, Australia	In front to CEDT, next to SERC
151	*Mesua ferrea* L.	Ceylon ironwood	Clusiaceae	Sri Lanka	NIAS
152	*Michelia longifolia* Blume	White champaka	Magnoliaceae	China	Professor's quarters area
153	*Michelia champaca* L.	Orange champak	Magnoliaceae	India, Malaysia	Student hostels area
154	*Millettia peguensis* Ali	Moulmein rosewood	Fabaceae	Myanmar	Next to SERC
155	*Millingtonia hortensis* L.f.	Indian cork tree	Bignoniaceae	Myanmar	Main Quadrangle, next to High Energy Physics
156	*Mimusops elengi* L.	Indian medlar	Sapotaceae	India	CST
157	*Mitragyna parviflora* (Roxb.) Korth.	True kadamb	Rubiaceae	India, Sri Lanka, Bangladesh	Miniforest
158	*Moringa oleifera* Lam.	Drumstick tree	Moringaceae	India	Nursery and Staff Quarters
159	*Morus alba* L.	White mulberry	Moraceae	China	Behind MRC
160	*Muntingia calabura* L.	Singapore cherry	Elaeocarpaceae	South America	At several locations on the campus, Nursery
161	*Murraya koenigii* (L.) Spreng.	Curry leaf tree	Rutaceae	India, Sri Lanka, China, Laos, Myanmar	Several trees occur scattered on the campus, particularly in the backyards of staff quarters.
162	*Neolamarckia cadamba* (Roxb.) Bosser	Kadamb tree	Rubiaceae	India	Behind Central Office building
163	*Ochroma lagopus* Sw.	Balsa	Bombacaceae	Panama, Columbia	Near CST
164	*Oncoba spinosa* Forssk.	Snuff-box tree	Flacouratiaceae	South Africa	On the roadside, Next to Nursery
165	*Parkia biglandulosa* Wt. & Arn.	Badminton ball tree	Fabaceae	Malaysia	In front of CEDT
166	*Peltophorum africanum* Sond.	African wattle	Fabaceae	South Africa	On either side of road from the second gate
167	*Peltophorum pterocarpum* (DC.) Back. Ex K. Heyne	Copper pod	Fabaceae	Sri Lanka, Sutheast Asia	On either side of the road from the second gate
168	*Persea americana* Miller	Avocado	Lauraceae	Southern Mexico	In front of CST, Vijnanapura campus
169	*Persea macrantha* (Nees) Kosterm.	Indian persea	Lauraceae	India, Sri Lanka	CES
170	*Phyllanthus acidus* (L.) Skeels	Star gooseberry	Euphorbiaceae	Brazil	Vijnanapura campus
171	*Phyllanthus polyphykkus* Wild.	Wild gooseberry	Euphorbiaceae	India	On the way to Jubilee Garden
172	*Pithecellobium dulce* (Roxb.) Benth.	Manila tamarind	Fabaceae	Mexico, S. America, West Indies	Vijnanapura campus
173	*Plumeria obtusa* L. var. sericiflora	Cuban frangipani	Fabaceae		
174	*Plumeri obtusa* L. var. obtusa	Temple tree	Fabaceae		
175	*Plumeria rubra* L. forma rubra	Pagoda tree	Fabaceae		
176	*Plumeria rubra* L. forma tricolor	frangipani tree	Fabaceae		
177	*Plumeria rubra* L. forma lutea	Yellow frangipani	Fabaceae		
178	*Plumeria rubra* L. forma acutifolia	Crimson temple tree	Fabaceae		
179	*Polyalthia longifolia* (Sonn.) Thwaites	Mast tree	Annonaceae	South India	As avenue trees in front of Civil Engineering
180	*Pongamia pinnata* (L.) Pierre	Indian elm	Fabaceae	India	Medicinal and Aromatic Plants Garden
181	*Pseudobombax ellipticum* (H.B.K.) Dug.	Shaving brush tree	Bombacaceae	Mexico	Next to Stores and Purchase, Main Guest House
182	*Psidium guajava* L.	Guava	Myrtaceae	Tropical america	VIjnanapura campus, Nursery
183	*Pterocarpus marsupium* Roxb.	Kino tree	Fabaceae	India	Next to Greenhouse in the Nursery
184	*Pterospermum acerifolium* (L.) Wild.	Dinnerplate tree	Sterculiaceae	India	Next to C mess
185	Pterygota alata (Roxb.) R. Br.	Buddha's coconut	Sterculiaceae	India	Behind Main Guest House
186	*Reutealis trisperma* (Blco.) Airy Shaw	Philippine tung tree	Euphorbiaceae	Malaysian Archipelago, Philippines	Next to Materials Research Centre, Vijnanapura campus
187	*Salix tetrasperma* Roxb.	Indian willow	Salicaceae	Southeast Asia, India	Swamp (P)
188	*Samanea saman* (Jacq.) Merr.	Rain tree	Fabaceae	Tropical America, West Indies	Next to Central Office on either side of the road
189	*Santalum album* L.	Sandal wood	Santalaceae	India	At several locations on the campus, a few specimens are next to Main Guest House
190	*Sapindus laurifolius* Vahl	Soapnut	Sapindaceae	South India	Airstrip area

Source: Trees of Bengaluru, ENVIS Technical Report 75, ENVIS, Centre for Ecological Sciences, IISc

1.4.2.4 Other List of Trees observed in Bengaluru

191	*Sapium sebiferum* (L.) Roxb.	Chinese tallow tree	Euphorbiaceae	China, Japan	Southeaast corner of Biochemistry
192	*Saraca asoca* (Roxb.) de Wilde	Flowering ashoka	Fabaceae	India, Sri Lanka	On either side of Central office building
193	*Schleichera oleosa* (Lour.) Oken	Lac tree	Sapindaceae	India	Faculty club
194	*Schotia brachypetala* Sonder	Tree fuchsia	Fabaceae	South Africa	Behind Physics
195	*Semecarpus anacardium* L.f	Marking nut	Anacardiaceae	Sub Himalayan (India)	Behind Wind Tunnel
196	*Sesbania grandiflora* (L.) Poiret	Vegetable hummingbird	Fabaceae	Indonesia	Nursery
197	*Shorea roxburghii* G. Don	White meranti	Dipterocarpaceae	India	Next to Water Tunnel Lab
198	*Simarouba glauca* DC.	Paradise tree	Simaroubaceae	North America	Biochemistry Quadrangle
199	*Spathodea campanulata* P. Beauv.	African tulip tree	Bignoniaceae	Tropical Africa	In front of Central Office Building
200	*Spondias pinnata* (L.f.) Kurz	Hog-plum	Anacardiaceae	India	Nursery
201	*Streblus asper* Lour.	Sandpaper tree	Moraceae	Sri Lanka, India	On the way to NIAS
202	*Swietenia macrophylla* King	Honduras mahogany	Meliaceae	Tropical America, Mexico, Brazil	Main Guest House
203	*Swietenia Mahagoni* (L.) Jacq.	West indian mahogany	Meliaceae	Caribbean Territories	Mahogany marg
204	*Syzygium aromaticum* (L.) Merr. & Perry	Cloves	Myrtaceae	Moluccas	Duplex Quarters
205	*Syzygium cumini* (L.) Skeels	Indian blackberry	Myrtaceae	South- & Southeast Asia	Next to Students Hostels area
206	*Syzygium jambos* (L.) Alston	Rose apple	Myrtaceae	Southeast Asia	Main Guest House
207	*Syzygium laetum* (Buch. -Ham.)	Madle	Myrtaceae	Endemic to India	Miniforest
208	*Syzygium nervosum* DC.	Rai jamun	Myrtaceae	India	Former Faculty Club
209	*Syzygium samarangese* (Bl.) Merr. & Perry	Java apple	Myrtaceae	Malay Archipelago	Nursery
210	*Tabebuia aurea* (Manso) benth. & Hook.f. ex S. Moore	Caribbean trumpet tree	Bignoniaceae	South America	Main Quadrangle
211	*Tabebuia chrysotricha* (Mart. Ex DC.) Standl.	Golden trumpet tree	Bignoniaceae	Brazil, South America	Next to Electrical Engineering
212	*Tabebuia impetiginosa* (Mart. Ex DC.) Standl.	Pink trumpet tree	Bignoniaceae	South America	In front of SID
213	*Tabebuia pallida* (Lindley) Miers	Cuban pink trumpet tree	Bignoniaceae	West Indies	Vijananapura Campus
214	*Tabebuia rosea* (Bertol) DC.	Rosy trumpet	Bignoniaceae	Tropical South America	At several places, behind MCB and in the Vijnanapura campus
215	*Tabernaemontana divericata* L. R. Br. Ex Roem. & Schult.	Pinwheel flower	Apocynaceae	India	Staff quarters
216	*Talauma mutabilis* Bl.	Kavthi Chapha-yellow	Magnoliaceae	Tropical America	Nursery
217	*Tamarindus indica* L.	Tamarind	Fabaceae	Tropical Africa	Next to MBU
218	*Tecoma castanifolia* (D. Don) Melch.	Chestnutleaf trumpet-bush	Bignoniaceae	Trop. S. America (Ecuador, Colombia)	Nursery
219	*Tectona grandis* L.f	Teak	Verbenaceae	Southeast Asia	Main Guest House, Miniforest
220	*Terminalia arjuna* (Roxb. Ex DC.) Wight & arn.	Arjun, white murdah	Combretaceae	India	Main Quadrangle
221	*Terminalia catappa* L.	Indian almond	Combretaceae	Andaman (India)	CES Quadrangle, in front of Materials Engineering
222	*Terminalia crenulata* Roth	Crocodile bark tree	Combretaceae	India, Southeast Asia	Medicinal and Aromatic Plants Garden, Gymkhana grounds
223	*Thespesia populnea* (L.) Sol. Ex Corr. Serr.	Portia tree	Malvaceae	India, Africa, Pacific Isles	NIAS
224	*Thevetia peruviana* (Pers.) Merr.	Yellow oleander	Apocynaceae	West indies	Next to High Energy Physics
225	*Tipuana tipu* (Benth.) Kuntze	Rosewood	Fabaceae	Northern Bolivia, Northern Argentina	Nursery, Main Quadrangle
226	*Toona ciliata* M. Roemer	Indian mahogany	Meliaceae	India, Southeast Asia	Behind Main Guest House
227	*Trema orientalis* (L.) Blume	Pigeon wood	Ulmaceae	India, Nepal, Polynesia, Australia, Tropical Africa	Ring road next to NIAS
228	*Vitex altissima* L.f	Chaste tree	Verbenaceae	Tropical Asia	Miniforest, Airstrip area
229	*Wrightia tinctoria* (Roxb.) R. Br.	Milky way	Apocynaceae	Indomalayan region	Next to MBU
230	*Ziziphus mauritiana* Lam.	Ber, Indian Jujube	Rhamnaceae	India	Main Quadrangle
231	*Parkinsonia aculeata* L.	Jerusalem thorn	Fabaceae	Subtropical America	Airstrip area
232	*Prosopis juliflora* (Sw.) DC.	Mesquite tree	Fabaceae	Mexico, S. America, Caribbean	Airstrip area

Source: Ramachandra T.V., Bharath H. Aithal, Vinay S., Rao G.R., Gouri Kulkarni, Tara N M and Nupur Nagar, 2014. Trees of Bengaluru, ENVIS Technical Report 75, ENVIS, Centre for Ecological Sciences, IISc, Bangalore 560012, Pp75

1.5 SHARED STREET

Shared streets often are referred to as “pedestrian priority streets”, “home zones”, or “woonerfs.” The street is shared by all users, designed to foster safety. Shared streets are designed to dramatically slow traffic through treatments such as brick paving, planters, and curves, in order to give priority to pedestrians over motorists and create awareness among all users.

Shared streets combine cycling, pedestrians, social activities, parking, and local car traffic to create a shared public space

Eliminating the traditional segregation of motor vehicles, pedestrians and cyclists can create a shared and more vibrant streetscape. Conventional devices such as kerbs, signs and signals are replaced with an integrated, people-oriented public space that encourages distinctiveness, social interaction, walking, cycling, universal accessibility, and reduced traffic speeds.

Location: Ranganatha Swamy Temple Road, Bengaluru.
Source: WRI India

Shared Streets generally contain similar characteristics:

kerb-free paving surface – no street level differences.
Signage – minimal road signage and fixtures.
Street gateway – a transition element encouraging speed reductions.
Reduced traffic speeds – visual street narrowing, street trees, landscaping, changes in materials and colors.

1.5.1 Design Principles

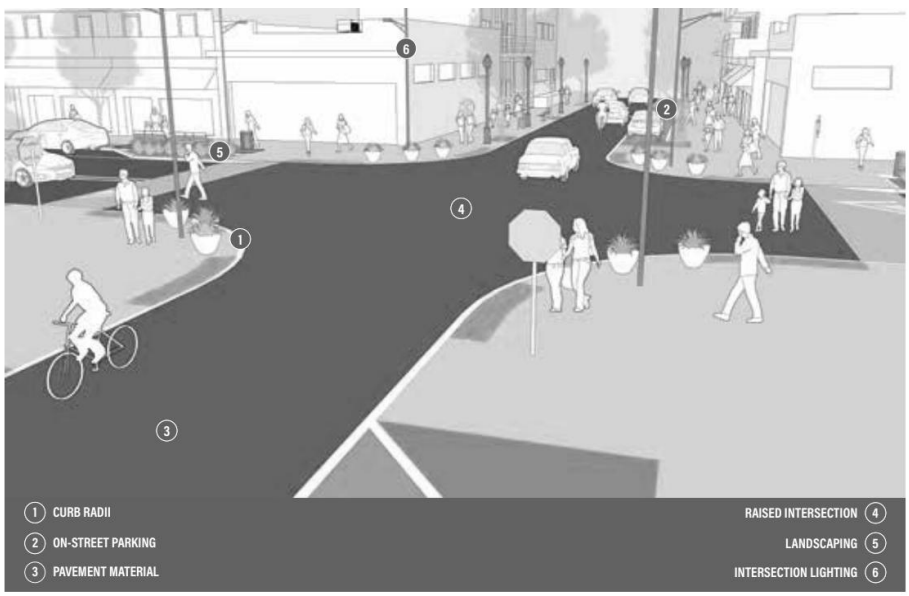
- Footpaths and kerbs are generally not used in shared streets, with fixed objects such as planters and trees acting as traffic calming measures to form chicanes, chokers, and other design measures to prioritize pedestrians.
- Enhanced paving, alternating pavers, and street furnishings within the street can be used.
- Plants and landscaping should be utilized to further improve the quality of walking.
- Maximum design vehicle speeds should stay at most around 15 km/hr.

1.5.1.1 Shared street designs should do the following:

- Encourage very low motor vehicle speeds and volumes with a design and target speed of 10 km/h.
- Distinguish the shared street from conventional streets through changes in surface texture and color.
- Avoid elements that suggest motor vehicle priority or segregation of modes, such as kerbs, pavement markings, etc.
- Include design elements that suggest pedestrian priority and the function of the street as a place for social, economic, and cultural exchange, such as street furnishings, gathering areas, lighting, etc.
- Address and carefully consider the navigational needs of people with disabilities.
- Provide a way for people with mobility impairments to access buildings.
- Include appropriate drainage designs for shared streets that do not have kerbs to channel rainwater.

Shared Street intersecting with another city street

Source: Low Speed Zone Guide, WRI



Raised Intersection on a Shared Street

Source: Low-speed Zone Guide, WRI

1.5.2 Traffic-Calming Measures for Shared Streets

- A shared street is one where the infrastructure is designed to meet the mobility and safety standards of all road users. It is essential that is meets the safety standards of the most vulnerable road users - pedestrians and cyclists.

- The implementation of traffic-calming measures is an essential component of creating safe, shared streets. In most built-up urban areas, it is impractical to provide dedicated lanes to every feeder mode due to pre-existing constraints, like availability of right-of-way, traffic dynamics or adjacent land-use conditions. Where possible and practical, one may consider off-road connectors, (through parks and public places); or off-grade infrastructure. However, the opportunities for such interventions are limited, or their installation is immensely expensive. They cannot be considered as a blanket resolution for all areas where street right-of-way is limited. The most practical solution then becomes the implementation of shared streets.

- The most important aspect of developing safe, shared streets is to slow down traffic speed. A slower street reduced the probability of conflicts between road users, while also reducing the severity of a crash when it happens. A second aspect of developing shared streets is the reduction of traffic volume, achieved mainly through the diversion of non-local traffic.

- In some contexts, certain motor-vehicle user groups may prefer a slower street. For instance, local traffic accessing adjacent properties, will have a slower speed expectation than thoroughfare traffic. Similarly, feeder buses may also prefer slower streets, due to their need to frequently stop to pick-up and drop-off passengers. This is also true of para-transit services that may prefer slower movement, while scoping for passengers.

Source: Cities Safer by Design, WRI

1.5.3 Surveys

1.5.3.1 Space Utilization (Activity Mapping)

A space utilization study is to be performed based on the following suggestions.
The utilization of space is to be calculated under the following categories, but not limited to, effective and ineffective carriageway, foot paths, vendors occupying footpath, effective foot paths for pedestrians, spill over from shops, designated and undesignated parking spaces, residual areas etc.
The existing space utilization, activities and utility areas are to be mapped for 3 times during the day – morning, afternoon, and late evening for 4 days (Tuesday, Thursday, Saturday and Sunday).
In addition, it shall also include the study based on existing literature and previously published works that describe how spaces are used and its surrounding areas during occasional festivities that take place weekly, monthly, seasonally, or annually.
Following are the suggested data to be analyzed and studies to be conducted:

1. Based on locations
2. Based on time of the day
3. Occasional festivities (daily, weekly – e.g.: Sunday Markets, monthly, seasonal, annual – e.g.: Karaga)
4. Existing Pedestrian Level of Service
5. Detailed mapping of Residual spaces
6. Overall Inferences

Location: Ranganatha Swamy Temple Road, Bengaluru.
Source: WRI India

1.5.3.2 Utilities and Amenities Mapping

Identify, locate, and document details of the following existing utilities both underground and above ground on the streets.

1. Utility lines such as water supply, sewerage, storm water pipes, power, OFC and telephone cables
2. Maintenance points in infrastructure requiring periodic access including junction boxes, valves, manholes etc.
3. Utility private or government connections / entry points and routes of utility lines from the main supply to individual properties like individual houses, shops, commercial buildings etc.

Identify, locate, and document details of existing amenities such as public toilets, benches, drinking water facilities, Solid Waste Management etc. It is suggested to also note the material and current condition of the documented utilities and amenities. All documented details are to be validated by the concerned departments.

1.5.4 Surveys for Shared Market Streets

1.5.4.1 Parking

The parking counts to be conducted along with identify types of parking including two-wheeler/ cycles/ cars/ Intermediary Public Transport (IPT)/ tempo-auto etc. Vehicle registration numbers and type of parked vehicles in and around the market street are to be noted along both sides of streets. Parking is to be noted for every 60 minutes for 16 hours for 4 days (Tuesday, Thursday, Saturday, and Sunday).

Following are the suggested data to be analysed and studies to be conducted:

1. Parking study
2. Parking duration
3. Parking capacity vs Demand (Level of Service of parking)

1.5.4.2 Street Vending

Vending counts are to be performed to identify the types of vendors i.e., movable/non movable/floor and kind of products sold. The number of vendors is to be counted for 16 hours for 4 days (Tuesday, Thursday, Saturday, and Sunday).

Following are the suggested data to be analysed and studies to be conducted:

1. Distribution of vendors with classification in map format (preferably GIS)
2. Types of vendors – Modes *(e.g. : handcarts, cycle, etc.)*
3. Types of vendors – Product type
4. Models of operation of vending *(symbiotic relationship with shopkeepers, etc.)*

1.5.4.3 Freight Movement

The following studies along with the Traffic Surveys and Parking Surveys mentioned previously in section.

Following are the suggested data to be analysed and studies to be conducted:

1. Type of freight *(motorised and non-motorised with sizes)*
2. Movement pattern of freight by types
3. Operation timings
4. Freight Parking with locations and duration

1.5.4.4 User Profile, Travel Patterns and Perception

Transport surveys are to be conducted and must include pedestrian counts and traffic counts. Detailed traffic origin-destination surveys are also to be conducted in order to identify source, destination, route and mode taken for travel and corresponding inferences are to be presented.

Following are the suggested data to be analysed and studies to be conducted:

1. Types of users and purpose of visit to
2. Origin - Destination Mapping and Modal Share
3. Understanding trips to the market street
4. Average time spent by a user in the market street
5. Vehicular movement patterns *(one way, two-way etc.)*
6. Pedestrian movement patterns
7. Commuting period of pedestrian
8. Classified vehicular volume counts and pedestrian volume counts at key locations
9. Understanding user perception
10. Overall Inferences

Following surveys *(but not limited to the mentioned)* are to be incorporated to achieve the results and outcomes for the above-mentioned studies:

1.5.4.5 Origin - Destination Surveys:

A minimum of 500 samples are to be surveyed to obtain details such as origin and destination, purpose, frequency, length, type of vehicle, occupancy etc. in and around the Area. The samples are suggested to be distributed as 10% Cars, 20% Auto Passengers, 50% 2-wheeler riders and 20% pedestrians. The samples are to be collected both while vehicles are parked and during thoroughfare (about 150 samples) through the market, during the same 16 hours as the traffic count.

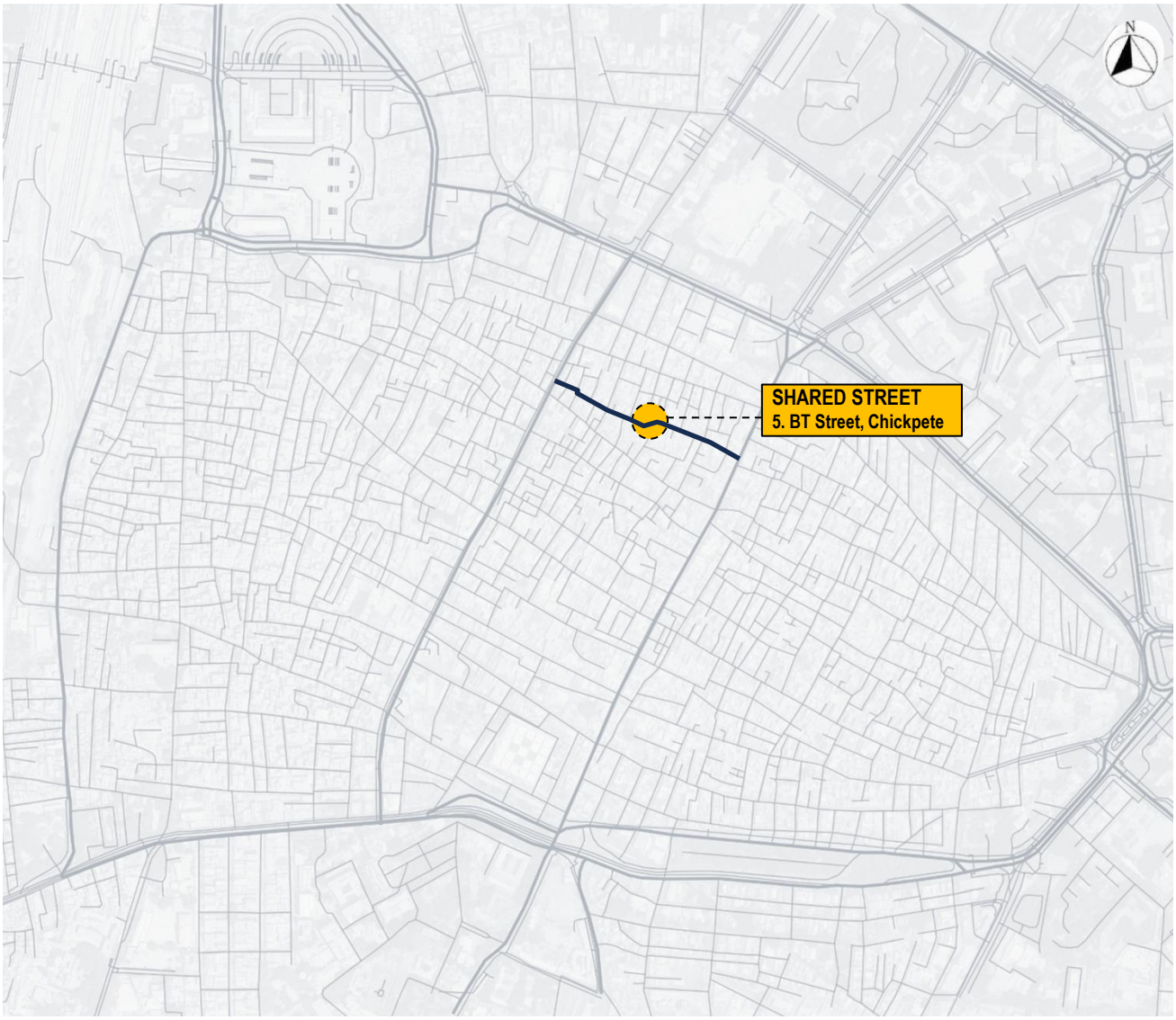
1.5.4.6 Traffic Surveys:

Traffic counts are to be performed for each direction for a minimum of 10 junctions (per phase) in and around the market street. Traffic is to be counted for 16 hours for 4 days (Tuesday, Thursday, Saturday, and Sunday) and data of pedestrians, cycles, two-wheelers, three wheelers passenger and freight, Light Commercial Vehicles (LCV), cars, buses, trucks and hand pulled carts, every 15 minutes is to be collected.

1.5.4.7 Perception Surveys:

Perception surveys of the shopkeepers and residents are to be conducted to understand the peoples' imagination of the public space and how it could be improved. Household/ shop perception surveys are to be undertaken for minimum of 500 samples in shops (constituting 350 samples, ensuring evenly spaced shops of different types) and houses (150 samples based on different types of construction) in and around the market street. The samples are to be chosen randomly, systematically covering all the profiles of shops and houses in the area.

NOTE: All the survey questionaries/ formats need to be reviewed by BBMP and concerned authorities and agencies before conducting the surveys.



1.5.5 CASE STUDY

SHARED MARKET STREET

BT Street, Chickpete

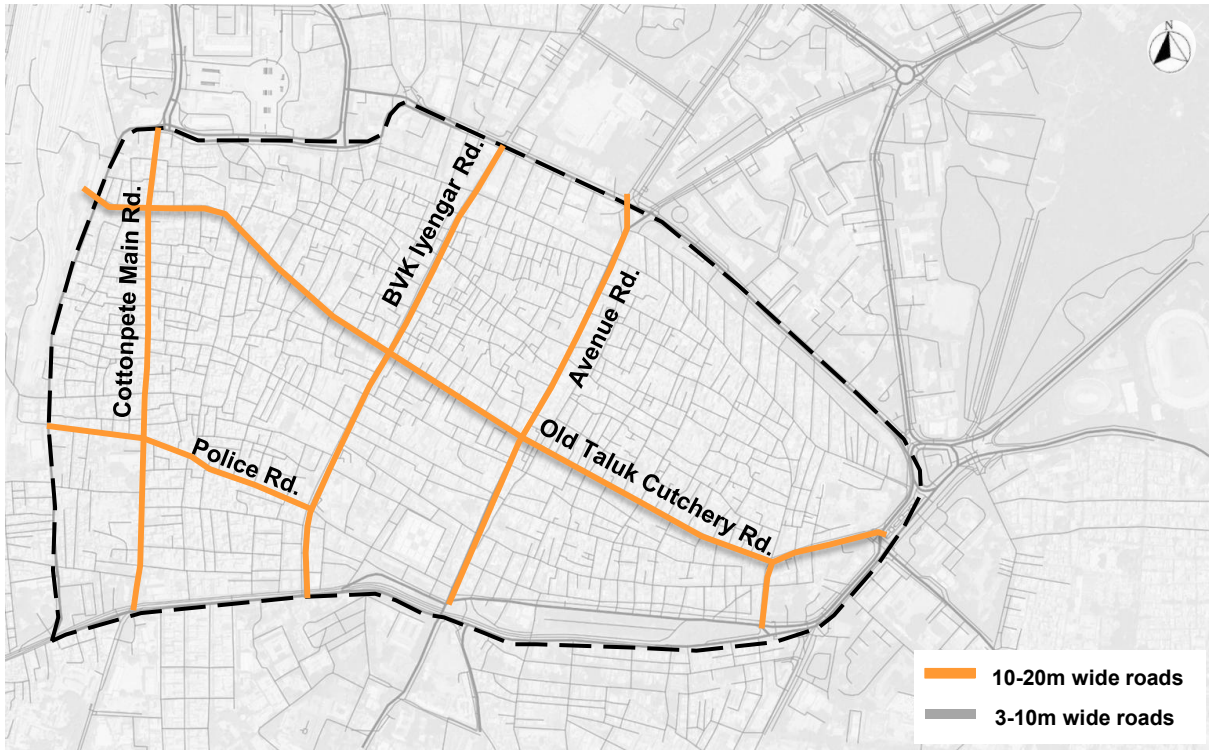
INTRODUCTION

Chickpete is one of the city's oldest and core commercial areas of Bengaluru, famous for its wholesale & retail clothes shops. The pete area had two main streets running along the North-South and East-West directions. One is Doddapete (meaning `Big City') that ran north-south and Chickpet or Chikkapete (meaning `Small City') that ran east-west.

The town grew to become a prosperous market city, with each neighborhood catering to different goods and services.

Like most places in old Bengaluru, Chickpete has also **transformed with time**. Most of its iconic shops and movie halls have made way for modern-looking stores and malls.

CHICKPETE AREA



EXISTING ROADS

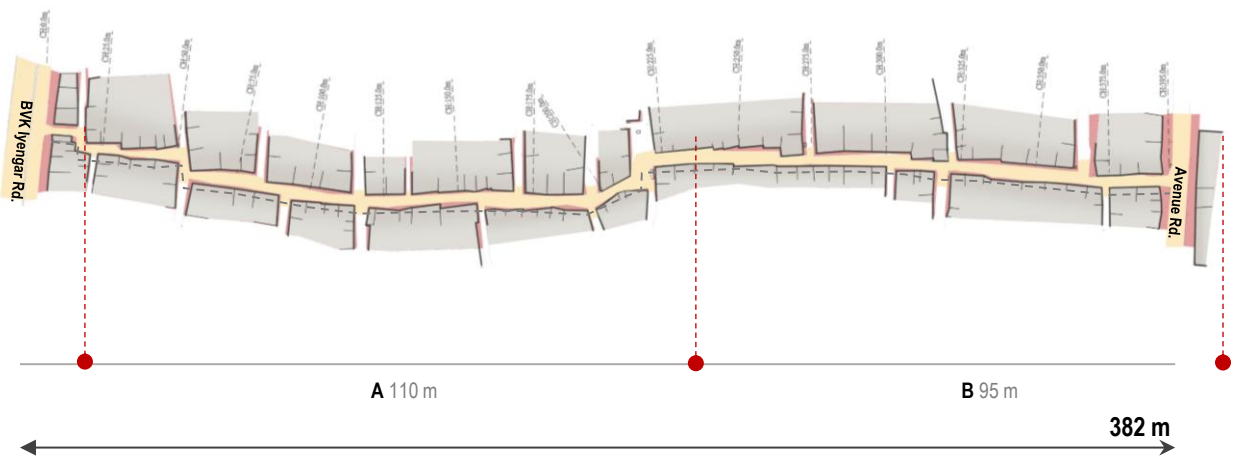
10-20 m Wide Roads – 5.8 kms

5-10 m Wide Roads – 48.4 kms

0-5 m Wide Roads

This market area can be made safer and more vibrant through provision of continuous and wider footpaths or partially pedestrianization of select streets, safe pedestrian crossings, designated vendor areas, park & walk facilities, and improving access to metro and bus.

BT STREET PLAN



Graphics: WRI India

BT Street is one of the typical narrow streets in Chickpete, with ROW varying from 2.5m (minimum) to 6m (maximum) in just a small stretch of 382m. It needs to be looked at as a partially pedestrianized street for better quality of life and ease of mobility

EXISTING CONDITIONS OF BT

Sewage Overflow

Solid Waste Dump

Utilities

Encroachment

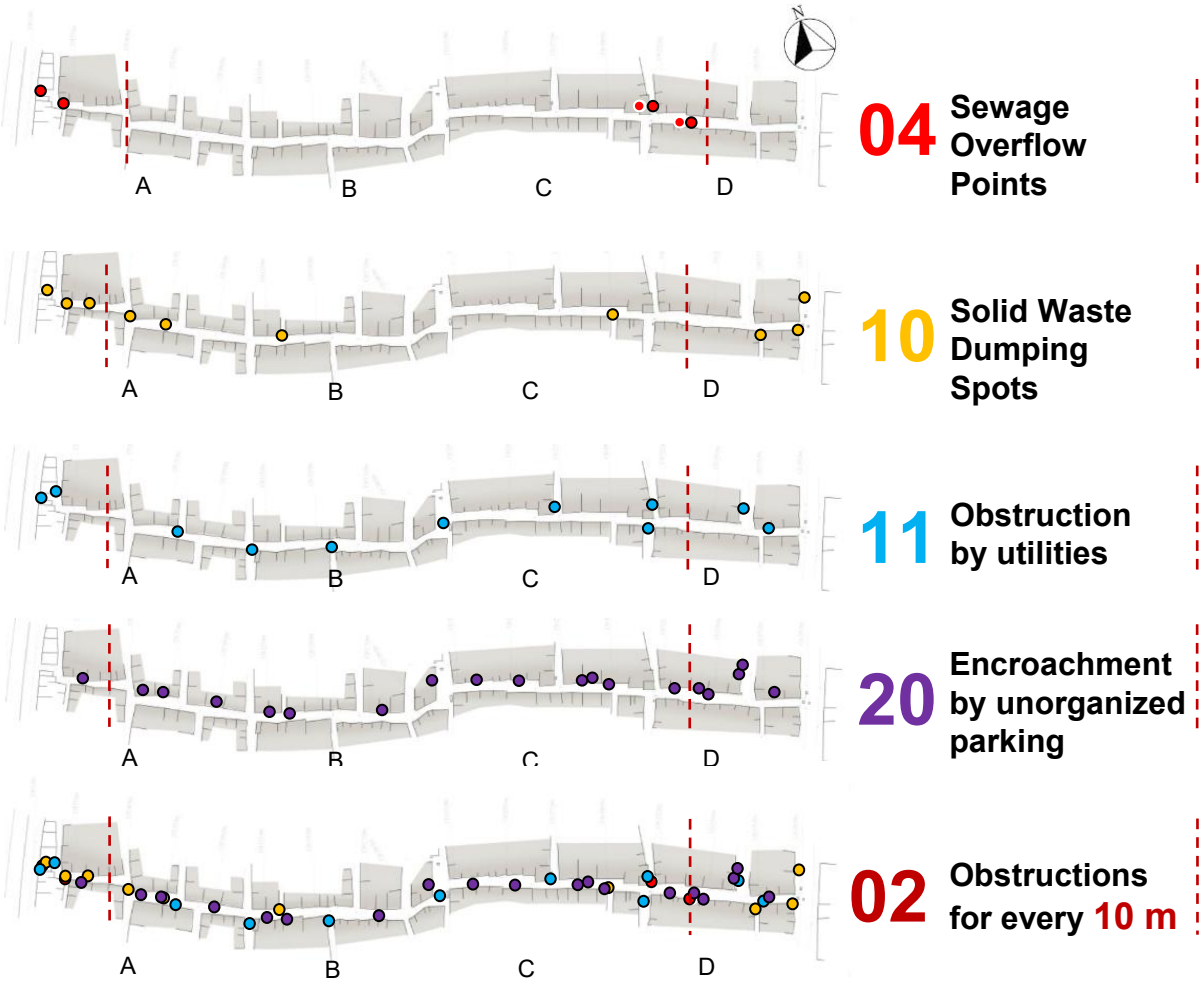
Uneven Carriageway Surface

Images: WRI India

Flooding & Water Logging

BT Street has similar issues as faced by almost all the streets in Chickpete area, like: Sewage overflow due to older utilities, dumping due to poor solid waste management, parking encroachment, uneven carriageway, flooding and water logging, etc.

ISSUE MAPPING



Graphics: WRI India

TABLE OF SUGGESTION

Issues	Suggestions
Sewage Overflow	• Improved lines and newer connections
Solid Waste Dump	• Identified collection points • Overall SWM plan
Utilities	• Streamlined Cabling • Smaller substations
Encroachment (Unorganized parking)	• Improved last-mile connectivity • Controlled Parking facilities

Above mentioned are some strategies and suggestions to improve the Quality of Life and Ease of mobility at BT Street. Most of these are also applicable to the other streets in Chickpete area. A detailed study like in the case study needs to be done on network of streets in Chickpete to improve the current image of Chickpete and also to increase its imageability.

PRINCIPLES OF DESIGN FOR SHARED MARKET STREET

Liveability

Sense of Place

Safety & Vibrancy

COMBINED UTILITIES

Integrated planning of multiple infrastructure services like water, electricity, sewage, and telecom

IRC:98-2011

SIGNAGE

Symbols that provide wayfinding, regulatory, informational in roads. They enhance navigation and improves safety

IRC:67-2012

STREET LIGHT

Fixtures installed along the median strip of a road to improve visibility, enhance safety, and guide traffic, especially at night.

IS 1944-1 and 2 (1970) Reaffirmed 2003

UNIVERSAL ACCESS

Ensures barrier-free mobility, equitable participation, and people of all abilities for a more accessible and livable city.

IRC:SP:117-2018

STREET FURNITURE

Benches or street furniture placed along pedestrian pathways to provide rest, enhance walkability, and improve public space usability.

IRC SP 117-2018

MATERIAL

Various materials such as cobblestone can be used in low-traffic and high-pedestrian areas

IRC:SP:020

STORM WATER DRAIN

Designed to collect and channel rainwater runoff, preventing flooding and waterlogging in urban areas

IRC:SP:50-1999

SWM COLLECTION POINTS

Involves the collection, transportation, processing, and disposal of waste to maintain cleanliness and sustainability

BOLLARDS

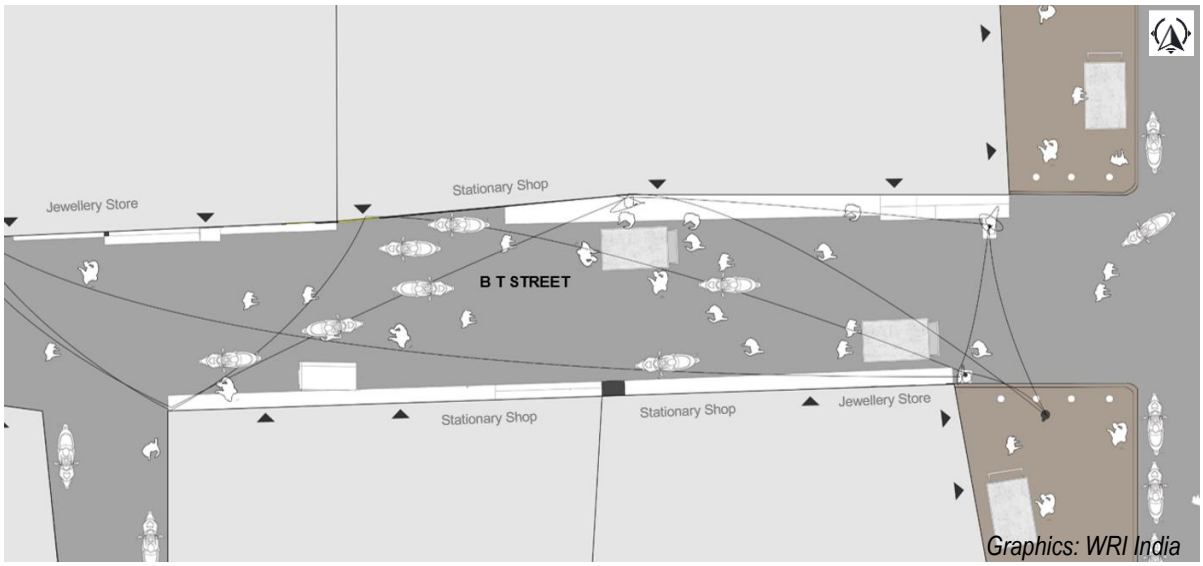
A short post used to stop vehicles from entering the footpath and to enhance pedestrian safety.

IRC SP 041-1994, IRC 103-2022

DUST BINS

Strategically placed containers for waste collection, promoting cleanliness and proper waste disposal

EXISTING CONDITIONS



STORM WATER DRAIN: Designed to collect and channel rainwater runoff, preventing flooding and waterlogging in urban areas.
IRC:SP:50-1999

STREET LIGHTING: Fixtures installed along the median strip of a road to improve visibility, enhance safety, and guide traffic, especially at night.
IS 1944-1 and 2 (1970) Reaffirmed 2003

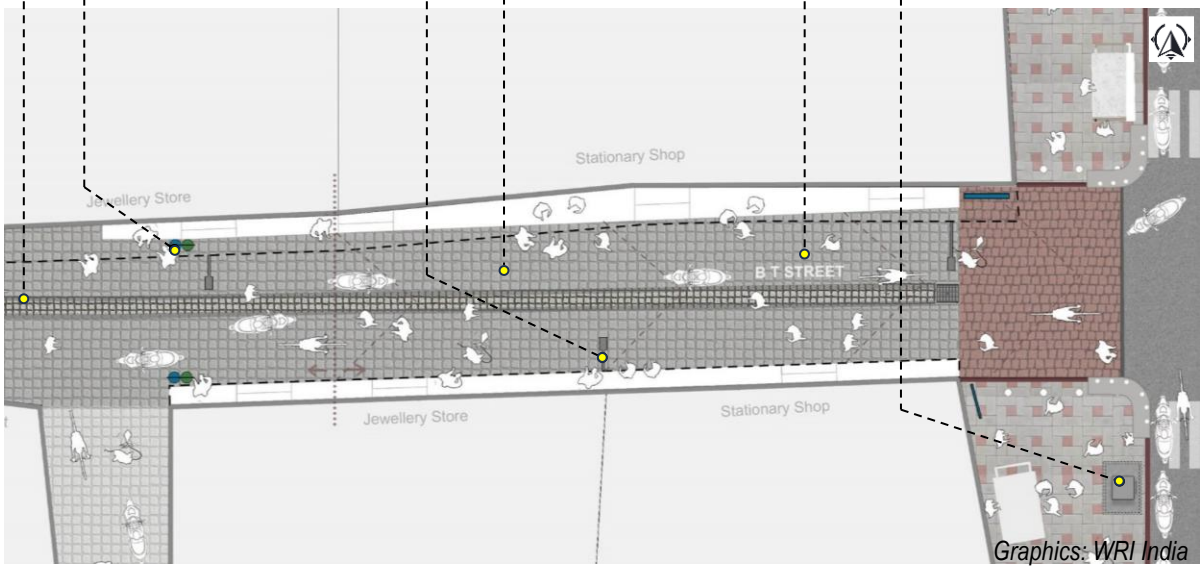
UNIVERSAL ACCESS: Ensures barrier-free mobility, equitable participation, and people of all abilities for a more accessible and livable city.
IRC:SP:117-2018

DUST BINS: Strategically placed containers for waste collection, promoting cleanliness and proper waste disposal.

COBBLE STONE: Natural stone material used for road paving, known for its aesthetic appeal and historical significance.
IRC:SP:020

SOLID WASTE MANAGEMENT: Involves the collection, transportation, processing, and disposal of waste to maintain cleanliness and sustainability

PROPOSED CONDITION



Provision of dustbins and shifting of storm water drains can eliminate accumulation of garbage and flooding. Using pavers for the entire surface conveys to all users that this is a shared street. Amenities like seating and lighting further improve the pedestrian experience.

EXISTING CONDITIONS

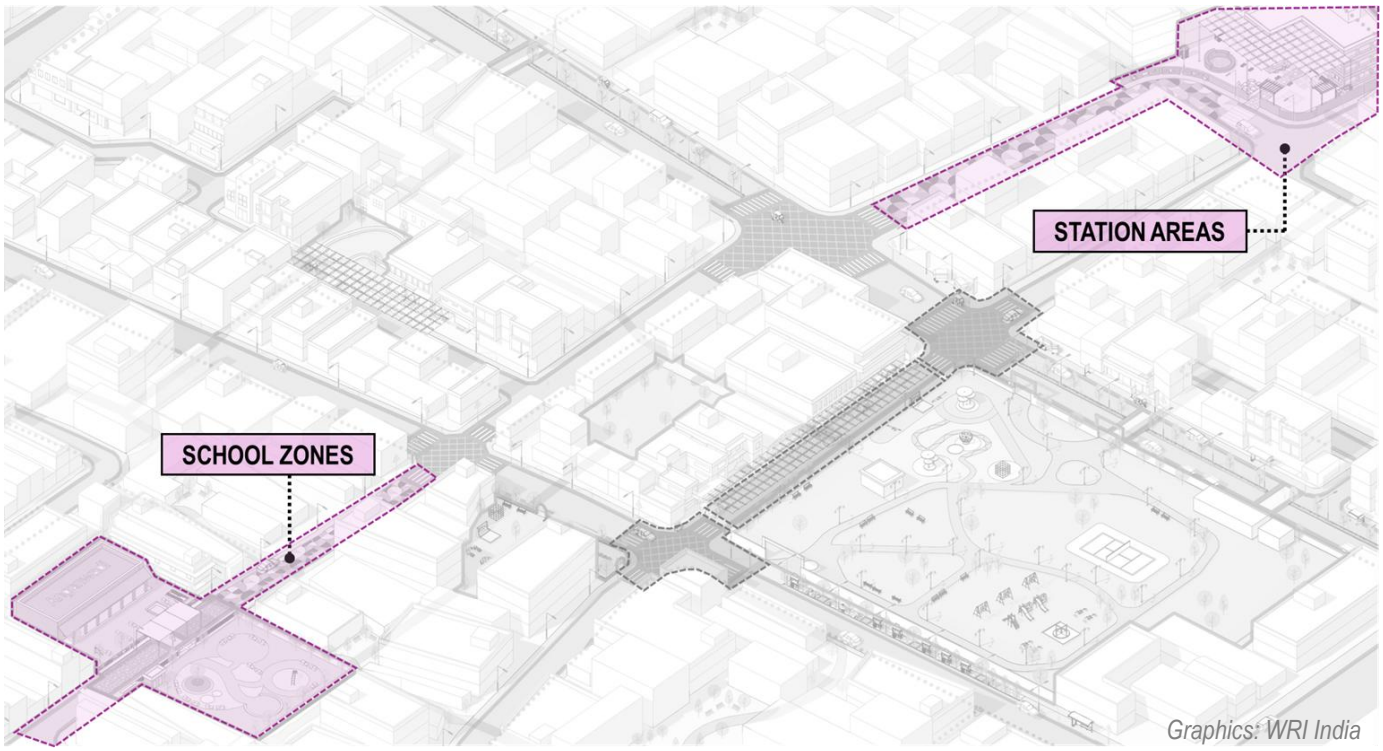
Image: WRI India

Current usage of the street by vendors indicates a local demand for such activities. However, these activities occur haphazardly, creating unusable street edges.

PROPOSED CONDITION

Graphics: WRI India

With better organization of vendor space, street edges can be better utilized for elements such as seating and lighting. These amenities can transform a shared street into places of recreation and socialization



2 | SPECIAL AREAS

Areas such as school zones and transit station areas in a city should be given greater attention due to high pedestrian and vehicular activity. Designing safe and accessible streets in these zones enhances safety for all users, particularly children, older people, and women. Essential elements may include well planned and wide accessible footpaths, street furniture and safe crossings. Establishing these safe zones also encourages greater public transport usage by improving walkability in the first and last mile, thereby improving access to transit stops.

This section outlines additional design standards specific to these high footfall areas, in addition to the general guidelines presented in the previous sections.

2.1 SCHOOL ZONES

According to IRC SP 32 - 2023, a school zone refers to an area around a school covering the road network that may encompass streets and roads, bus stops, intersections and parking areas or some of them depending on the type of development and the location of the school. Within this area, movement of higher number of children is expected, especially during the school opening and closing times.

Level of road safety within the school zones is highly dependent on its location, building layouts and age of students. It is therefore essential to design these areas using standards that are sensitive to the needs of school children and account for their specific requirements. The **IRC SP 32 - 2023** outlines these standards, which are briefly summarized in this section.

Source: IRC SP 32 - 2023

Definitions

According to IRC SP 32 - 2023, a School Access Zone (SAZ) may be understood as the road (s) leading to every entrance of a school, extending 100 m on either side of the school entrance (s). Unlike the SAZ which is limited to the streets along which a school's entrance is situated, the

School Proximal Zones (SPZ) shall include all roads within the applicable zone radius, excluding the SAZ.

2.1.1 Walking Infrastructure

For collector roads and above, raised footpath shall be provided on both sides of the carriageway, as per the dimensions and specifications mentioned in IRC:103 - 2022.
The pavement material for the footpaths shall conform to IRC:103 - 2022. However, owing to children's higher susceptibility to injury, softer materials should also be explored.
All provisions for universal accessibility shall be incorporated as per IRC:SP:117 - 2018 and IRC:103 - 2022.
The kerbside of the footpath in SAZ shall be provided with guard rails as per the details mentioned in the succeeding section.

2.1.2 Speed Management

Source: IRC SP 32 - 2023

IRC: SP 32-2023, 8.3.3

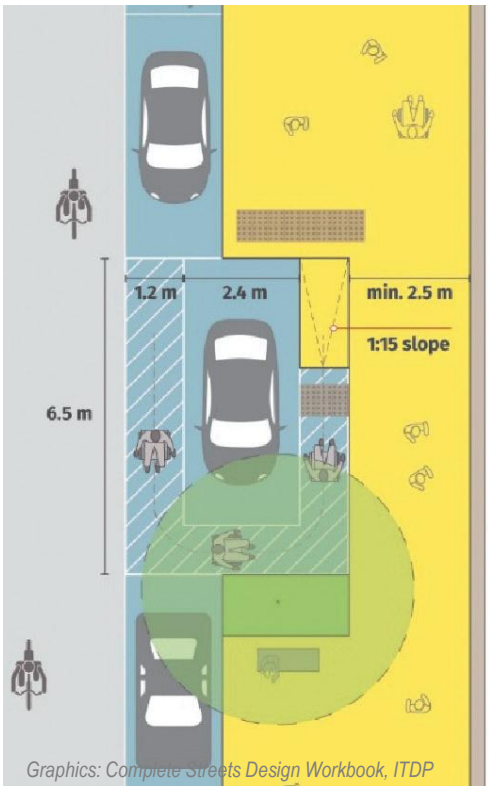
According to IRC SP 32-2023, there are two ways in which speeds may be limited in a school zone:

- Enforcing fixed speed limits
- Enforcing time - specific speed limits

Speed Limits and Methods of Enforcement in School Zones

Road Type	Prescribed Speed Limit (Kmph)		Preferred method for enforcing speed limits
	SAZ	SPZ	
Urban Roads /Interurban Roads	25	30	Time specific Speed Limit
Arterial Roads / Highways	25	30	Time specific Speed Limit
Collector Street / Other District Roads	25	30	Fixed Speed Limit throughout
Local Streets / Other Roads (including PMGSY Roads)	20	20	Fixed Speed Limit throughout

2.1.3 Pick & Drop off Areas



Graphics: Complete Streets Design Workbook, ITDP

Based on IRC SP 32 - 2023, The following design considerations shall be followed in the case of pick-up and drop-off areas for both school buses and private modes:

- As far as possible, pick-up & drop-off areas should be encouraged within the school premises itself to reduce the safety risk for children and avoid traffic congestion near entrance gates.
- The kerb height, from where children will board/alight, shall not be more than 150 mm and shall have a kerb ramp.
- They should have provisions for universal accessibility as elaborated in IRC:SP:117 – 2018 and IRC:103 - 2022.
- Wherever exclusive gates are not available for vehicular and pedestrian entry to school, traffic cones or other forms of channelizing devices should be used to minimize pedestrian and vehicle conflicts and manage traffic flow. Mode-specific considerations for pick-up and drop-off areas are given in subsequent sections.

2.1.4 Pedestrian Crossings

Graphics: IRC SP 32 - 2023

All pedestrian crossing facilities shall conform to IRC:103 - 2022, unless otherwise. These facilities should also ensure conformity to IRC:SP:117 - 2018.

- Table-top crossings (also called raised crosswalks) shall be the preferred design for crossings in school zones, as it brings the motorists and pedestrians at the same eye level. This is especially important for the safety of children.
- As both a marked crosswalk and a traffic calming element, table-top crossings provide a superior safety advantage to pedestrians.

- Table-top crossings shall be installed within 20 m of school entrance gate, to slow down vehicular traffic and allow students to cross to the other side as shown in the figure below.
- Wherever table-top crossings are not possible and crossings at the same level of the road are provided, kerb ramps, bollards, etc.,shall be provided as elaborated in IRC:103 - 2022.
- Foot-over bridges equipped with lift facility shall be permitted in unusual circumstances for schools located directly on arterial roads only conforming to IRC:103 - 2022.
- To make the information clear and accessible to children, pedestrian crossing signage should also be stamped on the footpath.
- 'Look Left/Look Right' text should be painted on the carriageway, and audio beepers shall be provided at the signals to inform the children with and without disabilities on looking out for vehicular traffic before crossing the carriageway.

Graphics: IRC SP 32 - 2023

2.1.5 Pedestrian Refuge Islands

Graphics: IRC SP 32 - 2023

- Pedestrian refuge islands shall be provided at every instance in the school zone, as per the guidelines provided below.
- Pedestrian refuge islands for crosswalks should not have a raised kerb and should not be less than 1.5 mi n width and 3.6 m in length. Openings or dropped kerbs should be provided in the centre island to allow for universal accessibility.
- Pedestrian refuge islands should be properly highlighted with the help of road markings and road furniture such as signage, median markers, or normal or solar studs based on the site requirement. This will help warn motorized vehicle users about the presence of pedestrians crossing.

- Standalone refuge islands can be provided in streets that measure 12 m or below in ROW and generally do not have medians. The width of such islands can be restricted to 1.2 m.
- 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 so that vehicles are forewarned of the impending obstruction on the road during the night.
- Zebra-crossing marking must be provided at such refuge island across the road.
- The refuge island should be invariably painted with red-and-white stripes as detailed in the section on road marking.

2.1.6 Public Transit Stops Within School Zones

Graphics: IRC SP 32 - 2023

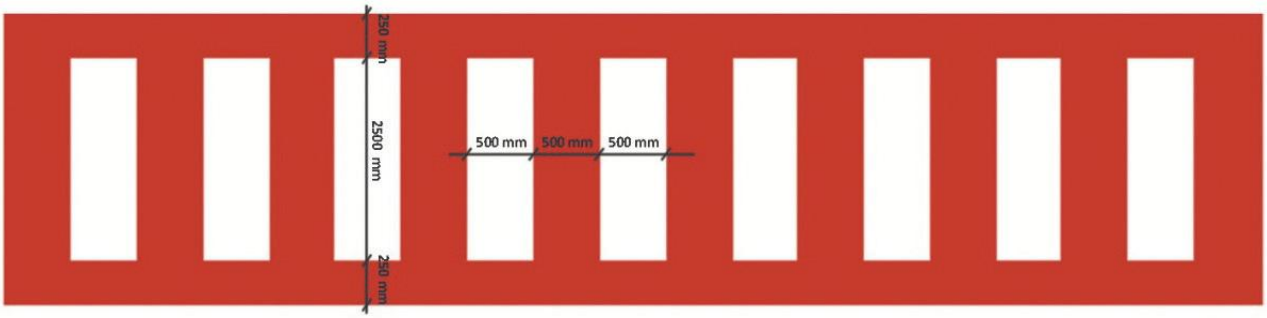
- To make sure that bus stops are accessible to children, height of the flooring of the bus stop should not be more than 150 mm.
- The design of stops should be such that it does not obstruct visibility of the surroundings and pedestrian flow on the footpath.
- Height of the seating should be less than that of the rest. Space for a wheelchair to park should be provided at all bus shelters.
- The design should be compact and robust with anti-skid and have levelled floor space and with preferably cantilever roof, sufficient shade, and light.
- Advertisements should not obstruct route information display maps, statutory signage, etc. The back panel should not be opaque, and advertisements should be placed in such a way that they do not block the vision for pedestrians.

2.1.7 Cycle Parking

Cycle parking should be provided inside the school premises. Wherever this is not possible, parking racks should be either the school authority or concerned civic authority along the compound wall of the school to allow for safe and secure parking (refer to the image provided).


Image: IRC SP 32 - 2023

2.1.8 Road Markings



Graphics: IRC SP 32 - 2023

Road markings can play a very important role in school zones, especially when there is a need to convey information to drivers while entering a school zone. Road markings in school zones shall adhere to IRC:35 - 2015, except for the following:

- All objects within the carriageway that were supposed to be with alternating black-and-yellow/black-and-white stripes (horizontal, vertical, or sloped) as per IRC:35 shall be painted as alternating red-and-white stripes in the school zone with 3D impression to be easily detected by white-cane users i.e. persons with visual impairments. All other conditions, dimensions, warrants, etc., defined in IRC:35 shall remain the same, except that the black and yellow/black and white colours should be replaced by red and white colours.
- Sections where some specific restrictions are enforced and were supposed to have a yellow-painted kerb as per IRC:35 shall be painted red. All other conditions, dimensions, warrants, etc., defined in IRC:35 shall remain the same except that the yellow colour should be replaced by red colour.
- As per IRC:35, pedestrian crossing (BM01/BM02/BM03) is painted as alternate white and black of 500 mm width each. The black, however, is the unpainted surface of the tar road; in the case of school zones, it shall be painted in red colour, instead. An additional 250 mm wide border in red colour shall be painted on either side of the pedestrian crossing, perpendicular to the direction of travel, as shown in the above image.
- For table-top pedestrian crossings in SAZ, colourful patterns are encouraged over traditional alternate white stripes. This is done to make the crossing more attractive for pedestrians, especially children, to use, as they are attracted to bright colours and patterns.
- All pedestrian crossings in the school zone shall have “Look Left” or “Look Right” painted at the start of the crossing. Graphic pavement marking on the cycle track shall be marked in a different colour as shown in the figure. As per IRC:35, speed breakers (BM05) are to be painted in a black-and-white chequer-block pattern. However, in the case of speed breakers provided in school zones, the black colour shall be replaced by red colour, and all other conditions, warrants, specifications, etc., mentioned in IRC:35 shall prevail. The same shall also be done for the sloped sections of table-top pedestrian crossings in school zones.
- In the SAZ, the speed limit signs, applicable for that stretch of road, shall be replicated onto the carriageway in the form of road marking for increased adherence. Such speed limit shall be painted in an elongated manner.
- In transition zones, zig-zag markings can be used to alert the motorists of the pedestrian crossing to ensure that they do not stop before the crossing but begin to slow down.

2.1.9 Signages

Graphics: IRC SP 32 - 2023

All signage in school zones shall conform to IRC:67. However, a few signage shall have special warrants in the school zone.

- At the edge of the transition zone, a 'School Zone Ahead' signage shall be erected in the direction going towards the school zone. This signage should also mention the distance to the SPZ and prescribed speed limits in the SPZ to enable motorists to transition into the applicable speed limits.
- At the other edge of the transition zone, where it overlaps with the SPZ, a 'School Zone Starts' signage, along with the prescribed speed limit on that road, shall be erected.

2.1.10 Signals and Beacons

Traffic signals in school zones, if provided, shall conform to IRC:93 in all respects, except for some as detailed in IRC SP 32 - 2023.

Pelican signals shall be installed for all directions of a pedestrian crossing. IRC:93 mentions the primary and secondary signal for regulating vehicular traffic. While there shall be no secondary signal for traffic signals, the concept shall be adopted for pelican signals. Thus, every pedestrian crossing shall have a primary and secondary signal, for each direction of movement with an audio announcement/beeper. Signal time should be calculated based on the walking speed of children and pedestrian traffic volume; this can be kept at least 20 - 25s.

Flashing yellow beacons are most effectively applied where drivers would not otherwise note school zone signage due to traffic conditions, speed of travel, or competing signage. They shall be provided at the start of the SAZ and at all midblock pedestrian crossings in the SPZ.

2.1.11 Parking

All on-street parking should be discouraged within SAZ, especially on the road adjacent to schools and during school hours. It shall be the responsibility of the SMCs to notify the local police about school hours, for appropriate enforcement.

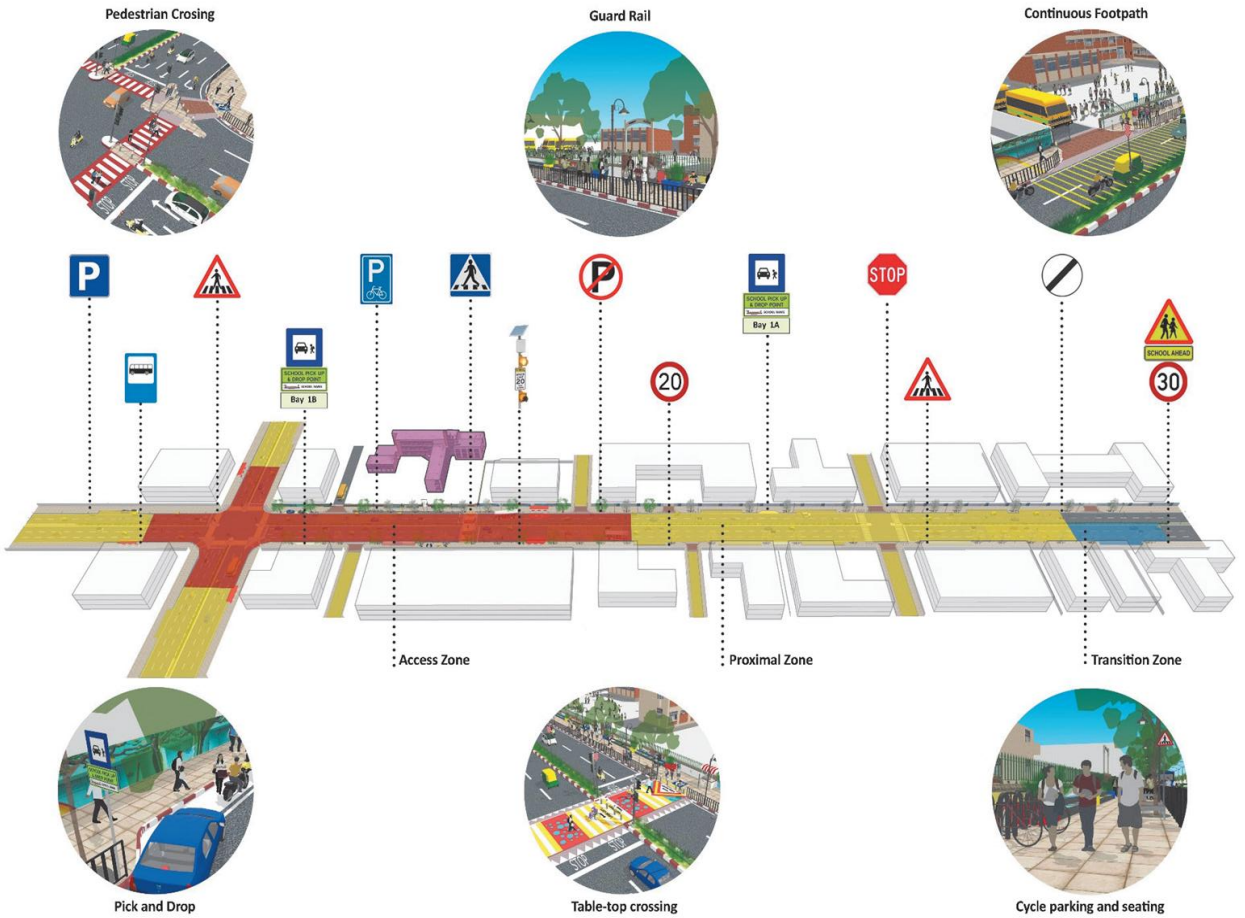
Wherever provided, on-street parking shall adhere to the standards detailed in IRC SP 32 - 2023.

2.1.12 Street Lighting

Streetlights (white colour is recommended) are to be provided to only make the pedestrian crossings visible but also have a psychological effect on motorists about something important. It automatically commands respect from motorists because pedestrians would be visible even from a good distance.

The specifications of each signage are detailed in IRC: 67.

2.1.13 Demarcation of School Zones



Graphics: IRC SP 32 - 2023

The Right to Education Act of 2009 provides for the constitution of a school management committee (SMC) consisting of elected representatives of the local authority, parents or guardians of children admitted in schools, and residents within the SAC.

SMC's may assist local authorities in the delineation of school zones by providing information on the number of students, number of students with disabilities; their entry/exit points; their mobility pattern in terms of mode of travel, commute distance, time, etc.; their mobility challenges and aspirations; and so on. Upon receiving the details, the local authorities shall be responsible for delineating and notifying the school zones.

Apart from assisting the local authorities in delineating school zones, the SMCs should maintain accessibility features, visual design scheme including wall-art, surface material, landscaping etc

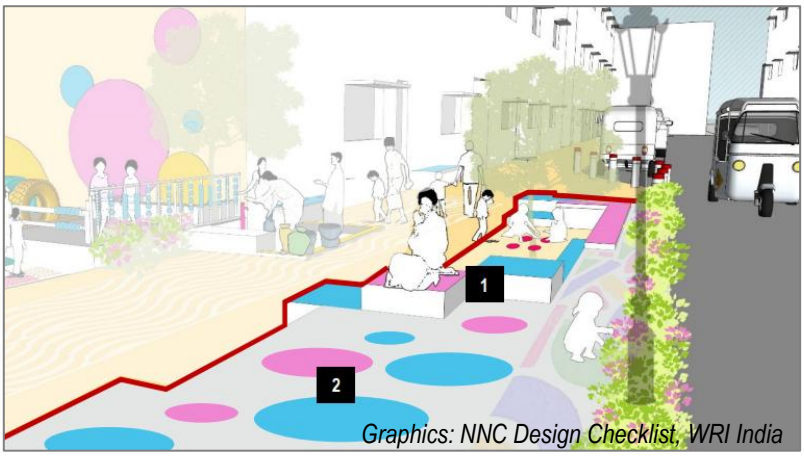
2.1.14 Place Making *(Asphalt Art and Interactive elements for School Zones)*

It is important to convey to all road users, especially vehicle users, if they are entering a school zone area. For this, it is required to have additional colours in this area in the form of artwork, signages, road markings, and street furniture. This can be done by using the exterior wall of the school boundary, colourful and more attractive designs for zebra crossings, etc.

Some guidelines considered marking the school zone as a 'Yellow Carpet Zone' to highlight the area for better concern of all road users. People in yellow-painted areas are more visible to drivers. They are also proven to create a 'nudge effect', motivating children to stay inside the yellow zone while waiting for a crossing sign and consequently reducing the chances of a risky crossing outside the crosswalks.

Different textures can also be used in road surface design with a combination of paving pattern and paint marking, as shown in the images below.

1. **Provide shaded clustered seating in the pause point to ensure eyes on the street**
2. **Provide interactive elements such as sidewalk games, interactive wall surfaces, sensory elements such as flowering plants in the pause points**

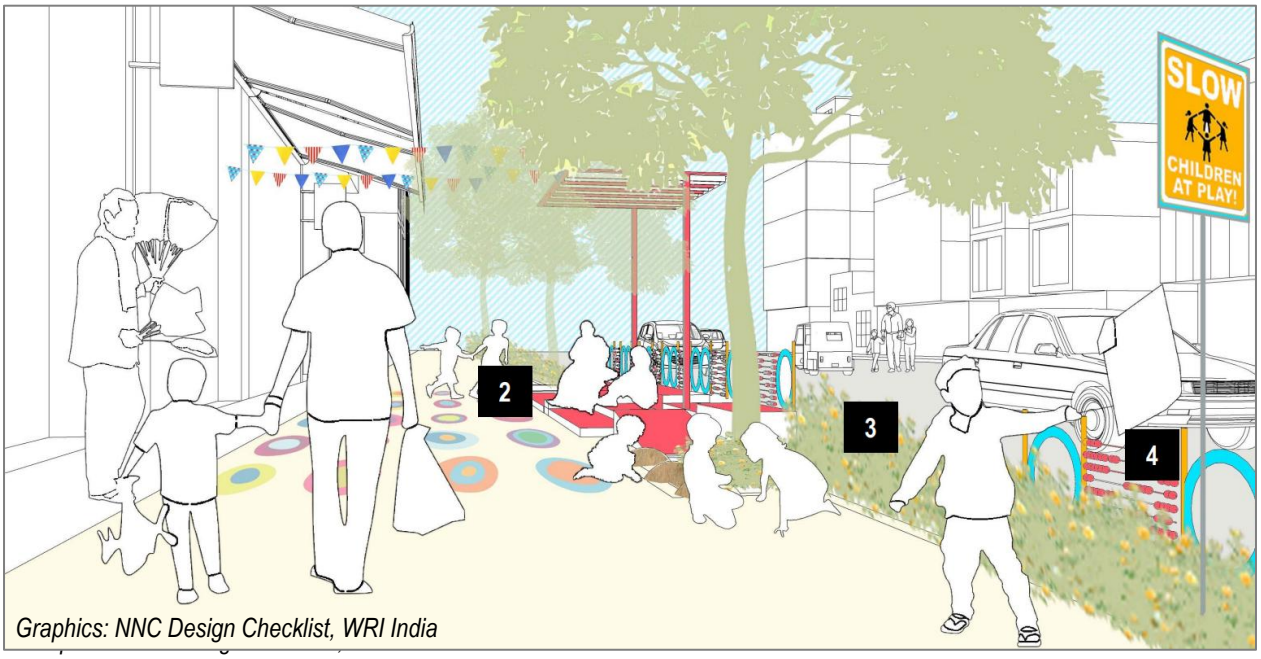


Graphics: NNC Design Checklist, WRI India

Project: 250m of Happiness, Delhi by HumanQind, Images: Chetan Sodaye/WRI India

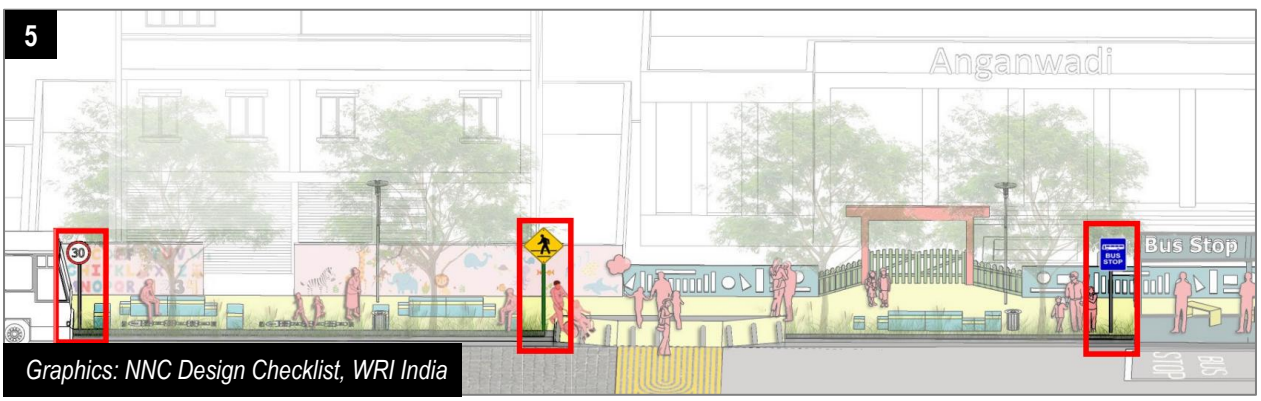
Stimulating experiences at 1m along footpath :

While streets are mostly used as movement corridors and extended spaces for recreation and interaction, it is important to provide stimulating experiences along the streets for young children. Footpaths should be provided with stimulating experiences at 1m height to engage young children. Informal play and sensory elements should be provided along the footpath to attract young children in the form of touch, smell, sight. These interactive elements maybe integrated in the rest and pause points.



Graphics: NNC Design Checklist, WRI India

1. **Provide pop-up play elements such swings, seesaw, etc. for play.**
2. **Provide floor and wall-painted games and colourful patterns as informal wayfinding as sidewalk games to engage children.**
3. **Provide variety of flowering plants at the green buffer to stimulate sensory experiences.**
4. **Provide interactive railings such as abacus railing at 95cm for play and protection.**
5. **Place the signages so that it is visible at an eye-level of 95cm**



Graphics: NNC Design Checklist, WRI India

2.1.15 CASE STUDY

SCHOOL ZONES

Near Jnana Sweekar Public School,
Kanakapura Road

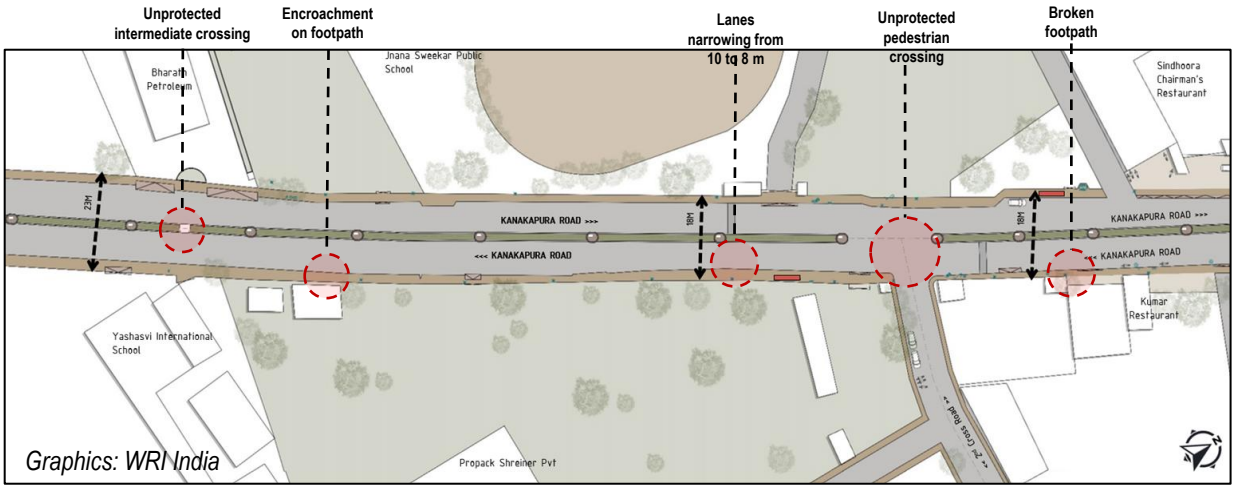
EXISTING CONDITIONS

Broken Footpath

Lack of Speed-Calming Elements

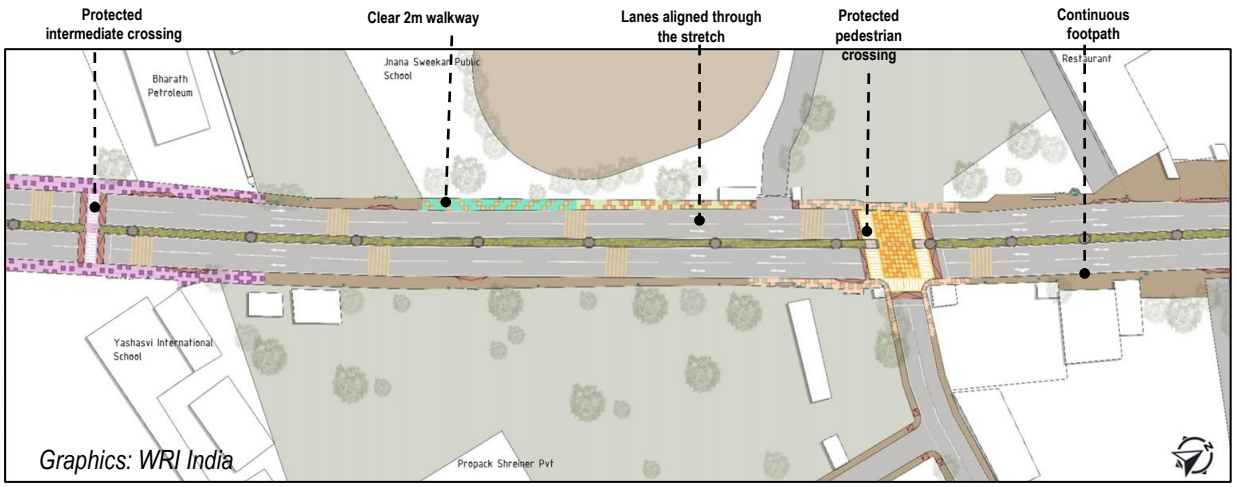
Unprotected Intersection

EXISTING PLAN



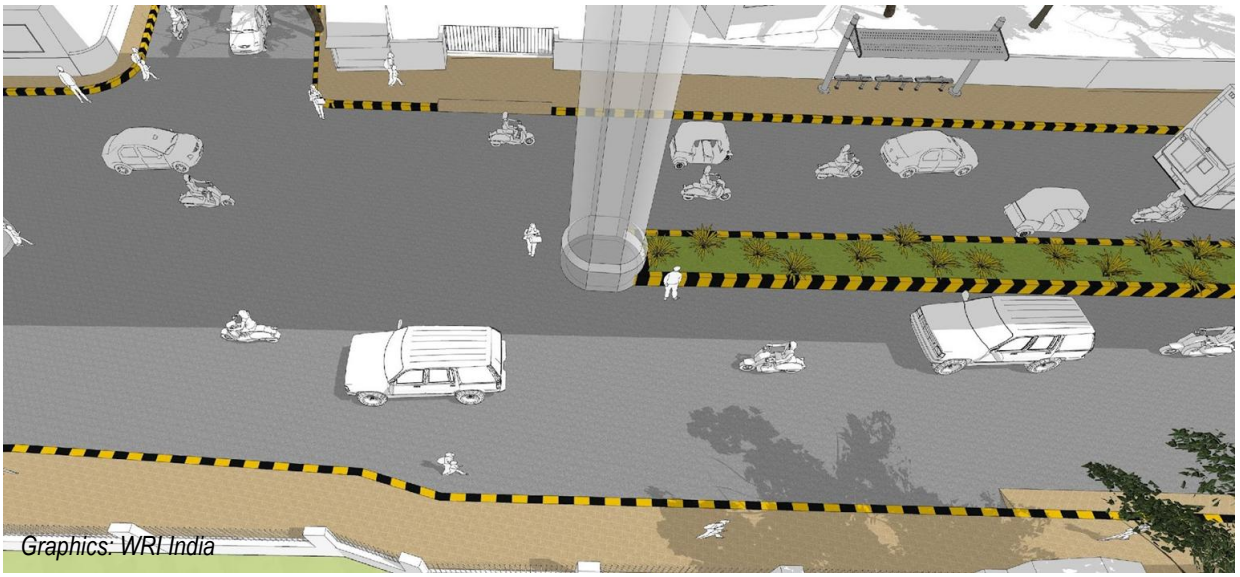
Children are particularly vulnerable on high-speed corridors due to their limited decision-making ability and judgement. The roads are unsafe due to unprotected crossings, broken footpaths, and lack of safe pedestrian infrastructure at junctions.

PROPOSED PLAN



This school area can be made safer for children and their caregivers by using elements of safer streets such as raised crossing, median refuge, rumble strips, pedestrian lights, and vibrant footpaths with interactive elements.

EXISTING CONDITIONS



PROPOSED CONDITION

***RAISED PEDESTRIAN CROSSING**: This elevated section of the roadway is designed for pedestrians to cross safely, intended to slow down vehicular traffic and improve visibility at crossings.*
IRC: 103-2022

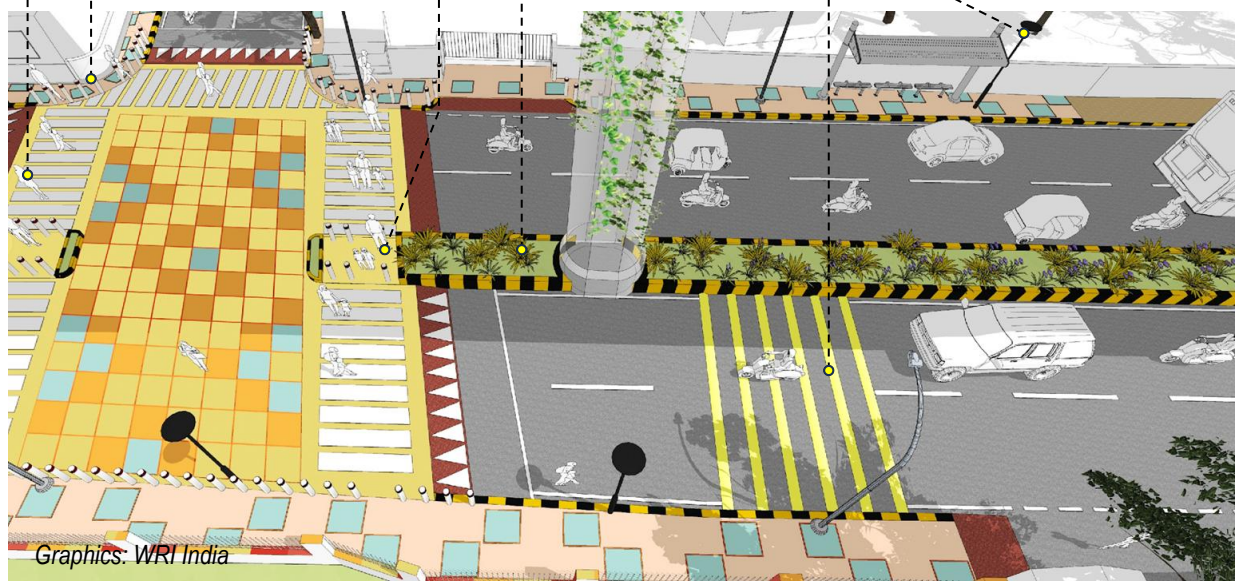
***BOLLARDS**: A short post is used to stop vehicles from entering the footpath and to enhance pedestrian safety.*
IRC 103:2022

***MEDIAN REFUGE**: This is a small section of median, completely surrounded by asphalt or other road materials, where pedestrians can stop before finishing crossing a road.*
IRC: 103-2022 'Guidelines for Pedestrian Facilities' IRC: 35-2015 'Code of Practice for Road Marking'

***MEDIAN VEGETATION**: Vegetation is planted in the center strip of a roadway to enhance aesthetics, improve air quality, and provide a natural barrier for traffic safety.*
IRC SP: 21-2009

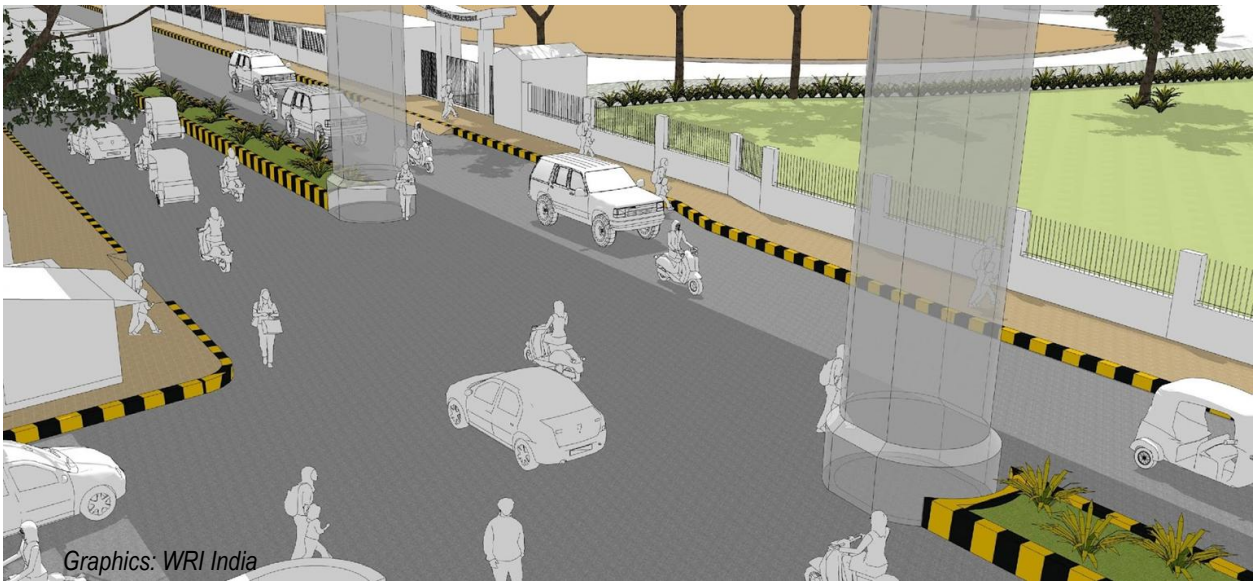
***RUMBLE STRIPS**: Speed calming elements are used to reduce the speed of vehicles on the main carriageway.*
IRC: 99-2018

***PEDESTRIAN LIGHTS**: Outdoor lighting fixtures are installed along the roads, sidewalks, and public spaces to enhance visibility, safety, and security during night time.*
SP 72: 2010



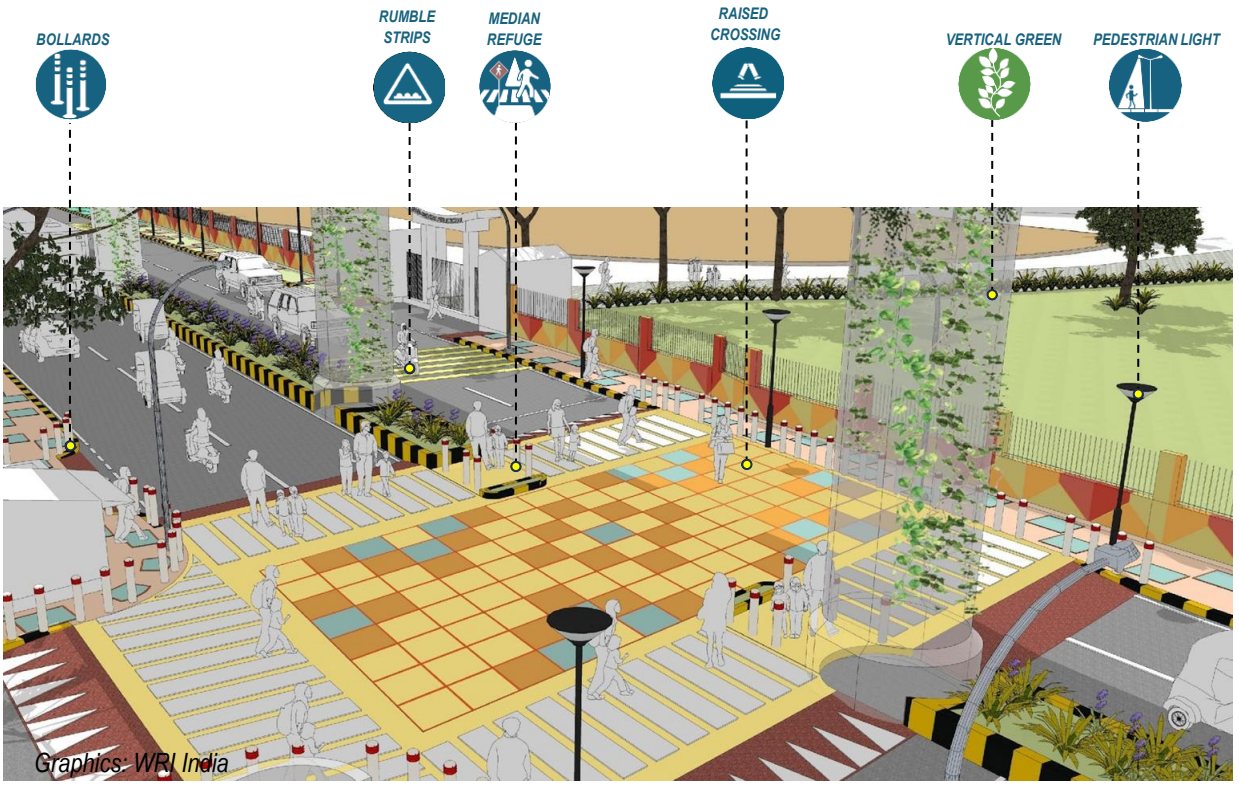
Raised interactions are necessary when it comes to safe access to schools. Rumble strips can be used to reduce the speed of vehicles on the main carriageway. Bright asphalt art at the junction brings more attention from the drivers, making it further safe for children and their caregivers.

EXISTING CONDITIONS



Intersections with no pedestrian infrastructure lead to multiple conflict points on arterial corridors. Analysing and understanding pedestrian crossing behaviour at such locations is vital for improving road safety in school areas.

PROPOSED CONDITION

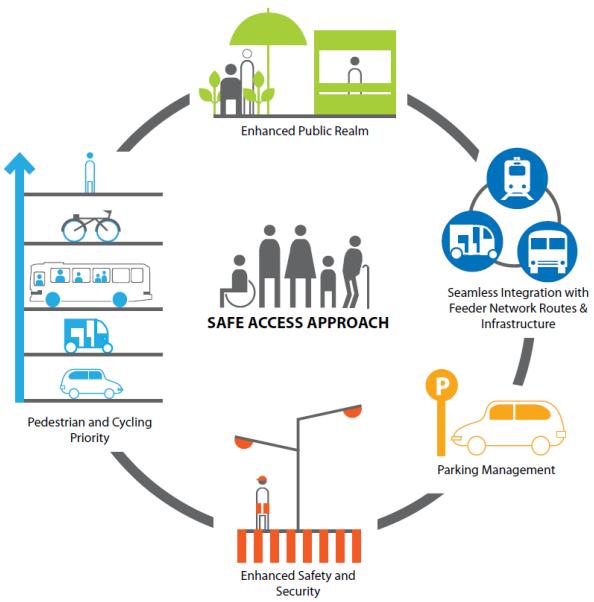


Raised intersections are junctions where the entire intersection is raised at the footpath level with ramps on all approaching roads, slowing down the vehicles by giving priority to pedestrians. This is very helpful to improve safety in school areas.

2.2 STATION AREAS

Station area design and planning are crucial for creating well-connected, vibrant, and sustainable communities around transit hubs. This promotes walkability, reduces congestion, and encourages public transit use by integrating housing, businesses, and public spaces. By focusing on efficient land use, station area planning ensures that transit investments benefit both residents and businesses.

This section highlights some strategies and approaches for enhancing station accessibility with a people-centric focus. A well-planned station area, guided by a safe access approach, prioritizes pedestrians and cyclists, ensures seamless integration within a multimodal network, enhances the public realm, and fosters economic vibrancy, all within a safe and secure environment. By facilitating easy and safe access, well-designed first and last mile enable more comfortable and time-efficient travel.

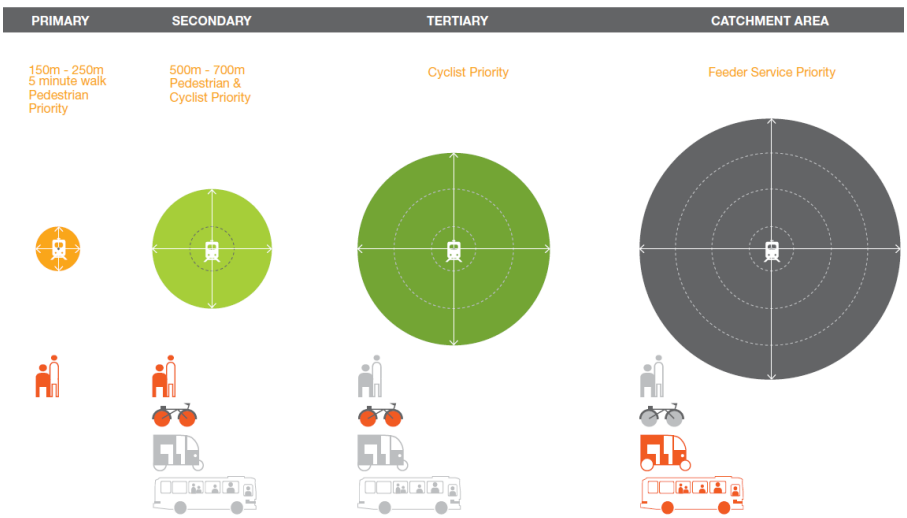


Graphics: WRI India

2.2.1 Station Area Planning

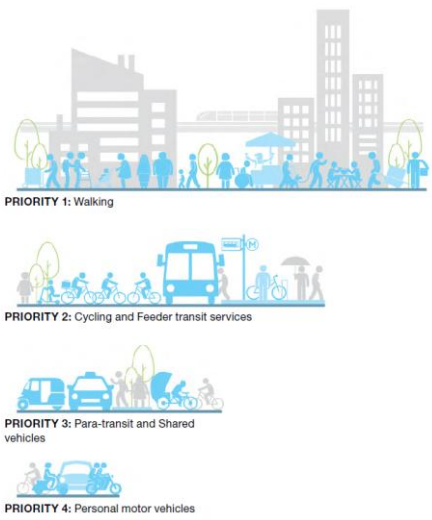
A station area is more than just an area adjacent to a transit node. It is a place of connectivity where different modes of transportation–from walking to riding transit-come together seamlessly and where there is a concentration of working, living, shopping, and playing. A well-functioning station area is defined by more than its adjacency to a mass transit station. A station area is described by the ease and number of connections it offers its users and the multiple activities that occur here.

The transportation and land-use conditions typically vary with distance from the transit station. When planning in a station area, it is useful to divide it into zones to scope the planning exercise and understand the needs and opportunities in each area. For example, direct and safe walking connections are most important in close proximity to the station, where there is often the highest levels of pedestrian activity. Farther away from the station, bicycle, bus, and rickshaw/taxi connections become relatively more important to ensure convenient access. The station area's boundary includes primary, secondary, and tertiary zones. The catchment area includes the larger feeder area for the mass transit station.



Graphics: WRI India

The primary station area refers to the area immediately surrounding the transit station, i.e. within 0 – 400m or 5 minutes walking, where the transfer of commuters between feeder modes and the main transit line takes place. This is the meeting point for the trunk routes of all feeder modes. Hence, safety and mobility challenges are the most crucial at the station area, given the high concentration of commuters and traffic into a relatively small space. Infrastructure for the transfer of pedestrian commuters should be provided nearest to the station gates, followed by infrastructure for cyclists and feeder buses, then para-transit, and finally personal motor vehicles.



Adaptation of hierarchy of priority for mobility planning, prominent in many global cities, is at the forefront of sustainability. This hierarchy of priorities is all the more relevant for station areas, given the focus of moving people away from personal vehicles and onto transit. The following section outlines key strategies and guidelines for improving station accessibility through a people-centric and sustainable development approach.

Graphics: WRI India

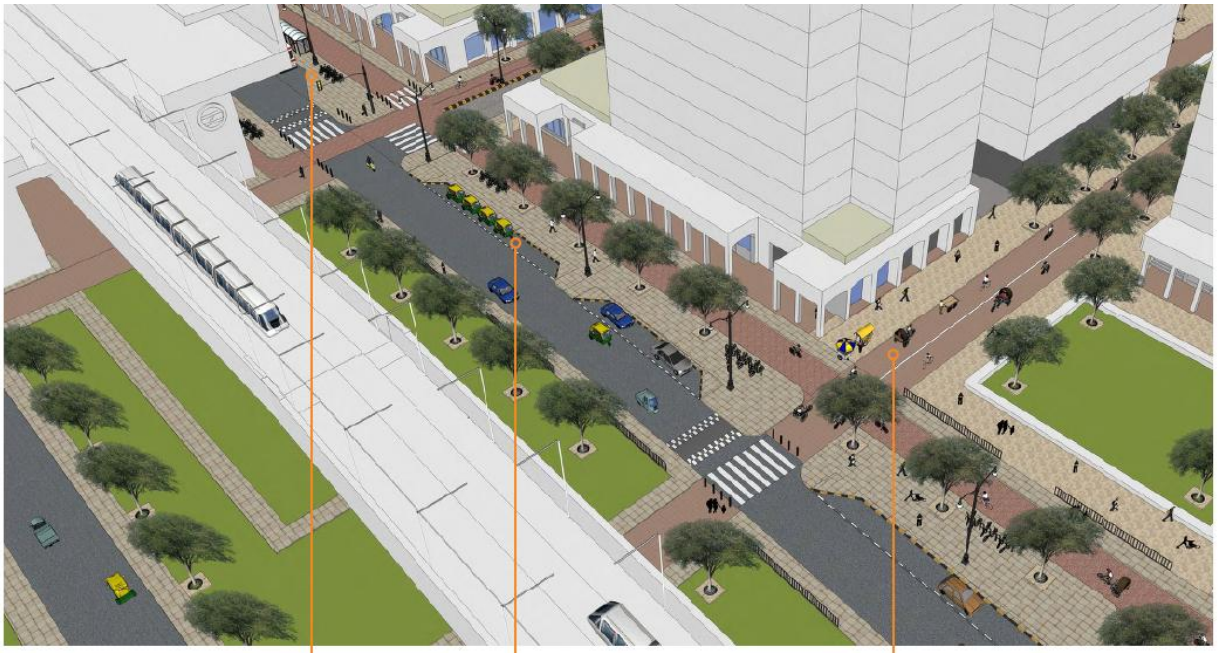
2.2.2 Walking and Cycling Infrastructure

Graphics: WRI India

IRC 103-2022: Guidelines for Pedestrian Facilities introduced a level of service approach for designing footpaths along with guidelines to facilitate universal access and incorporate street vendors, street furniture, and utilities. IRC 86-2018: Geometric Design Standards for Urban Roads in Plains recommends cycle tracks of 2–3 m for arterial, sub-arterial, and collector roads. Prioritizing non-motorized transport (NMT) access aims to reduce walking and cycling distances, create connected and complete networks, improve pedestrian and cycling infrastructure, and create a high-quality public realm that supports street-level activity and uses. The station accessibility plan also needs to account for future NMT growth, infrastructure, and amenities. The table below recommends strategies and guidelines for prioritizing NMT in station areas.

Strategies	Guidelines
Create a continuous and connected pedestrian and cycling network.	• Identify major destinations and create direct, shortest pedestrian and cycling routes to the station. • Create 'green grids or networks' through existing public open spaces and along rivers and natural drains within the station area. • Integrate grade-separated access to key destinations from stations.
Connect existing city-level routes or local routes to the station.	• Map the existing pedestrian and cycling networks within and through the station area and connect these to the station.
Evaluate and provide safe and comfortable pedestrian infrastructure.	• Understand the walking patterns, demography, trip purpose, needs, and perceptions. • Evaluate the level of service of pedestrian infrastructure along major routes within the primary and secondary zones. • Create street-rating maps to evaluate the quality of existing pedestrian infrastructure, universal access, road safety, and security. • Traffic-calm the station area and design streets and intersections to facilitate safe pedestrian access
Evaluate and provide safe and comfortable bicycling infrastructure.	• Understand the cycling patterns, demography, trip purpose, needs and perceptions. • Create street-rating maps to evaluate quality of existing cycling infrastructure. • Traffic-calm the station area and design streets and intersections to facilitate safe cycling access. • Provide sufficient, protected, and secure bicycle parking.
Improve pedestrian and cyclist convenience by providing amenities.	• Provide amenities through design, planning, and regulatory recommendations to improve pedestrian, cyclist, and user conveniences. • Consider public-bicycle sharing schemes between major destinations and stations.

2.2.3 Multimodal Integration

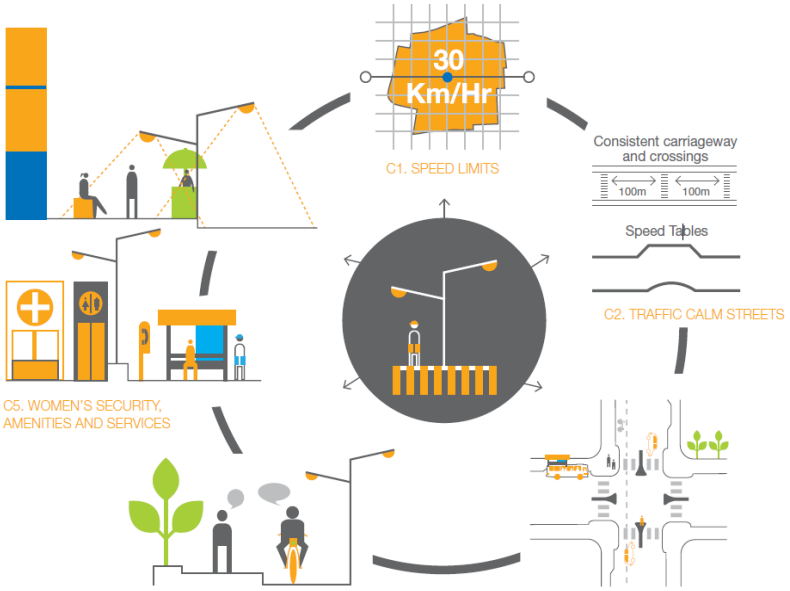


Graphics: WRI India

It is important to seamlessly integrate the feeder bus, rickshaw and taxi services with mass transit stations to reduce waiting times and discourage the use of private vehicular modes for last-mile connectivity and hence demand for vehicular parking. These provide an opportunity to increase the catchment areas of mass transit, especially in lower-density station areas. These services should be characterized by short-distance routes and high-frequency services. The table below recommends some strategies and guidelines for tackling challenges for multimodal integration.

Strategies	Guidelines
Provide and coordinate feeder-bus services and routes within the station area to minimize waiting times.	• Provide and coordinate feeder-bus service schedules and routes with regional, and mass transit services.
Adopt bus-priority measures to encourage the use of feeder-bus services and ensure efficient movement to and from the station area.	• Develop a transit-priority program to encourage the use of feeder-bus services for men and women. • Restrict or prohibit motorized vehicular parking within the primary zone of the station. • Consider dedicated bus lanes with priority signals within the station area, when required by traffic congestion. • Consider signal priority at congested intersections and at stations to speed up access in and out of station. • At bus terminals or depots, minimize conflicts by providing dedicated access points for buses and clearly demarcated protected passenger waiting areas. • Design terminals and bus shelters to a high level of comfort.
Facilitate access by auto-rickshaws, cycle-rickshaws, and taxis.	• Provide pick-up and drop offs by cycle-rickshaws, auto-rickshaws, and taxis (whenever relevant) without restricting bus, pedestrian, and cycling access at the station area. • Propose rickshaw or taxi stands (as relevant) at major destinations along with resting or seating facilities. • Consider shared auto-rickshaw and taxi services between the station and major destinations.

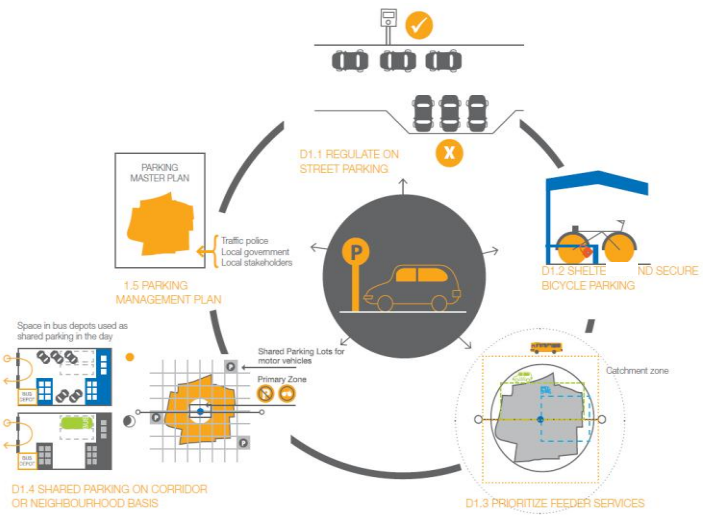
2.2.4 Safety and Security



Graphics: WRI India

The most vulnerable road users are pedestrians and cyclists. Urban roads and station areas, particularly, are characterized by a heterogeneous traffic mix, a variety of NMVs besides bicycles, high pedestrian density, poor traffic rules awareness, poor discipline and enforcement; significant road edge development, street vendors, and utilities. These need to be considered when designing for road safety. Additionally, there has been increased focus on how urban environments are inaccessible for people who are differently-abled and unsafe for women, and therefore their accessibility needs must be incorporated to create a safe and secure station area. The diagram above details some strategies to enhance the safety and security in station areas.

2.2.5 Parking Management



Graphics: WRI India

The concept of managing parking for sustainable growth has now started to gain traction in the city. Parking management is focused on travel demand management by regulating the availability of parking to induce a mode split. It is therefore essential to create a parking management plan with the objective of minimizing the need and supply of parking that regularizes on-street vehicle parking provision for equitable distribution of road space for pedestrians, cyclists, and transit feeder services along with other above-mentioned strategies.

2.2.6 Place Making

Image: Unkown


Image: Lynn Friedman

Place making re-imagines public spaces as the heart of every community and is considered a transformative approach that inspires people to create and improve their public places. Due to the dense context of station areas, design strategies such as multi-functionality of street furniture is recommended. For example, low compound walls or concrete pedestals of utility boxes can also become seating. The following strategies and guidelines illustrate how street furniture and signage can enhance the quality of the public realm.

Strategies	Guidelines
Undertake activity counts and map different types of street activity and uses.	• Map the different types of activities, nodes, their locations, and times within the station area and understand their relationships. • Undertake activity counts in different types of public spaces and nodes.
Enhance the role of streets as public spaces.	• Design streets to cater to multiple activities. • Enhance or design NMT priority and NMT-only streets to facilitate movement and as public spaces.
Create a secure, comfortable, and imageable public realm.	• Propose contextual, coordinated, and comfortable types of street furniture for all users. • Propose secure, sheltered parking for bicycles. • Propose comfortable, light and transparent bus shelters. • Propose different types of seating and waiting depending on the surrounding context. • Use utility boxes and transformers as public art. • Propose community and garbage bins. • Propose street lighting for carriageway and pavements. • Incorporate street vending in street design. • Incorporate landscape elements into the street design. • Design well-ventilated, simple public toilets with high architectural standards. • Incorporate public art to create place markers.
Introduce a coordinated pedestrian and traffic signage system to improve safety and way-finding.	• Introduce traffic signage to guide vehicular traffic. • Introduce a coordinated pedestrian signage system.

2.2.7 CASE STUDY

STATION AREAS

Near Sarakki Metro, Kanakapura Road

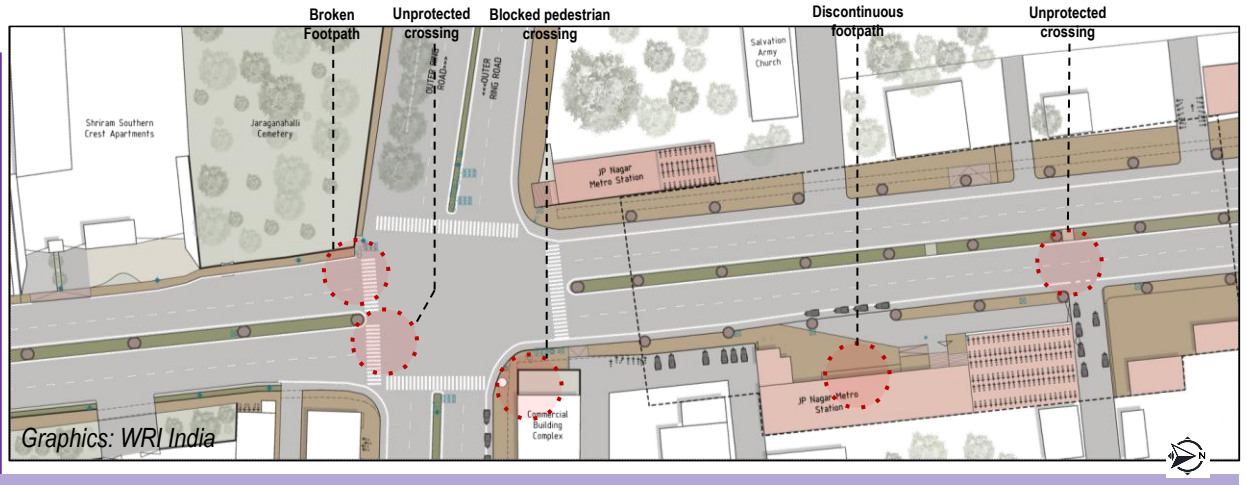
EXISTING CONDITIONS

Broken Footpath

Blocked pedestrian crossing

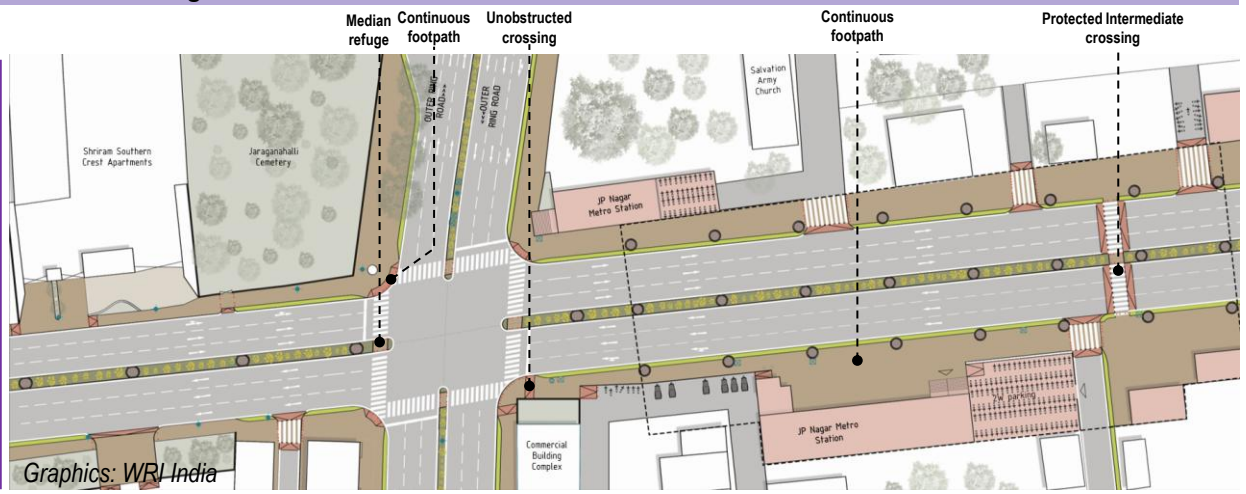
Unprotected pedestrian crossing

EXISTING PLAN



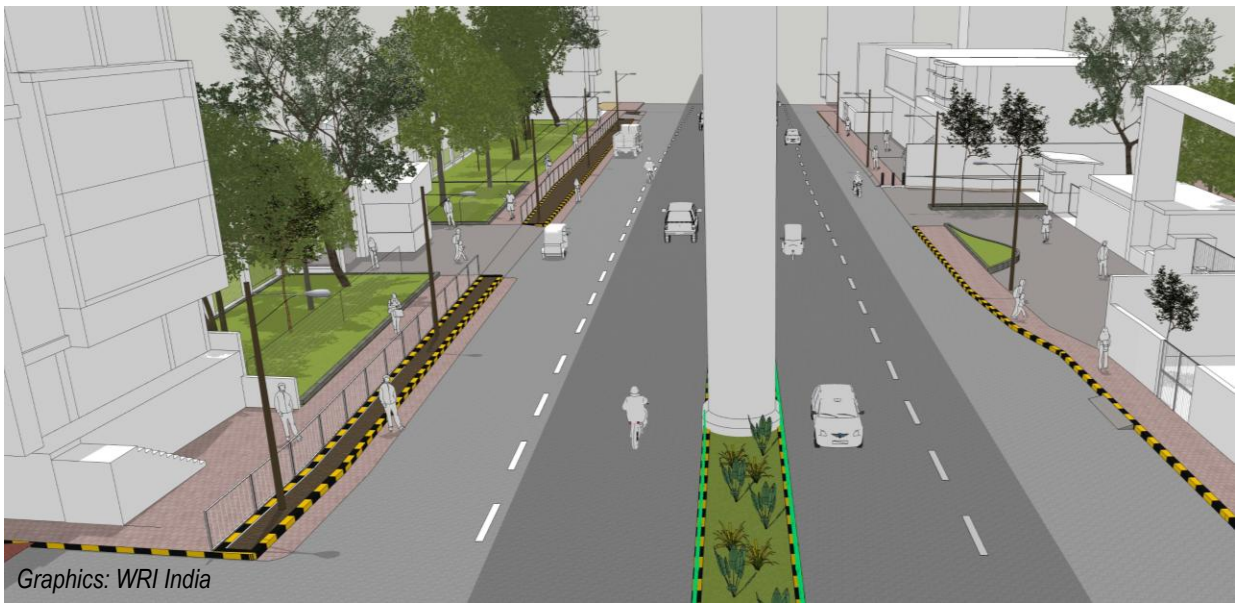
The JP Nagar metro station attracts metro users on walk as well as two wheelers for parking. This rises the need to fix issues like broken and discontinuous footpath, unprotected crossing and blocked crossing.

PROPOSED PLAN



This station area can be made safer through speed calming elements like HRPC raised pedestrian crossing accompanied by rumble strips, safety elements like median refuge and provision of unhindered continuous footpaths.

EXISTING CONDITIONS



RAISED PEDESTRIAN CROSSING: An elevated section of the roadway designed for pedestrians to cross safely, intended to slow down vehicular traffic and improve visibility at crossings.
IRC: 103-2022

BOLLARDS: A short post is used to stop vehicles from entering the footpath and enhance pedestrian safety.
IRC SP 041-1994
IRC 103:2022

PEDESTRIAN LIGHTS: Outdoor lighting fixtures are installed along roads, sidewalks, and public spaces to enhance visibility, safety, and security during night time.
SP 72: 2010

MEDIAN VEGETATION: Vegetation is planted in the center strip of a roadway to enhance aesthetics, improve air quality, and provide a natural barrier for traffic safety.
IRC SP: 21-2009

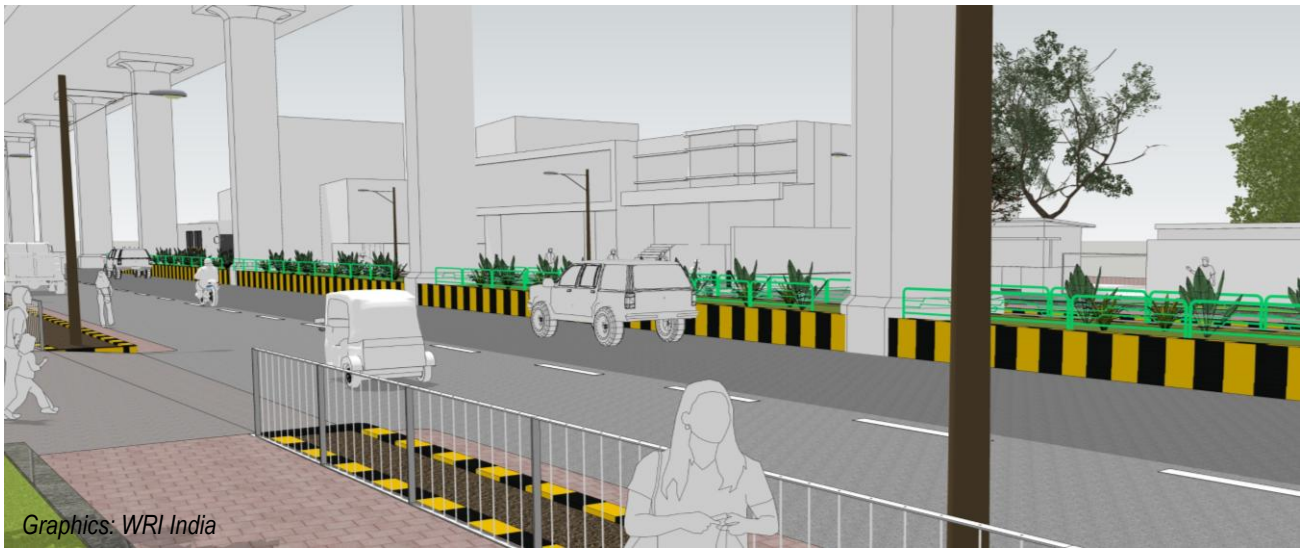
VERTICAL GREEN: *Integration of plants on vertical surfaces to enhance urban greenery, sustainability, and aesthetics.*
IRC SP: 41-2016

STREET LIGHTS: Fixtures installed along the median strip of a road to improve visibility, enhance safety, and guide traffic, especially at night.
IS 1944-1 and 2 (1970) Reaffirmed 2003

PROPOSED CONDITION

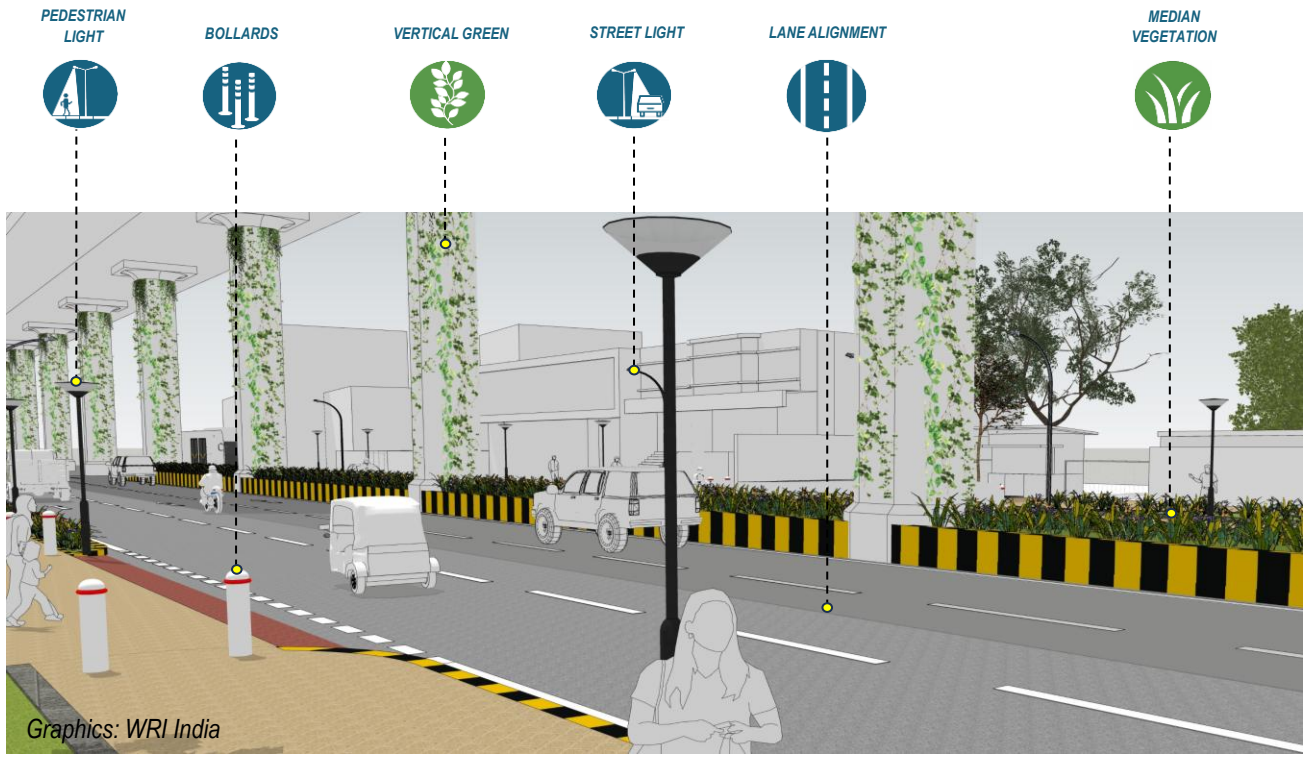
HRPCs raised pedestrian crossings along with bollards enhance the safety of pedestrians on high-speed corridors. They lower speeds closer to the crossing, making it safer for pedestrians as well as vehicular traffic.

EXISTING CONDITIONS



Railing on edge of footpath makes it inaccessible for pedestrians, forcing them to walk on the carriage way in unsafe conditions.

PROPOSED CONDITION



Due to high pedestrian volumes in the station areas, there is a need for more pedestrian friendly infrastructure with safety elements like bollards and ramps for universal accessibility. Pedestrian lights, paint marking and adequate refuge areas help making it safer for all.

03 ENGINEERING

3. ENGINEERING

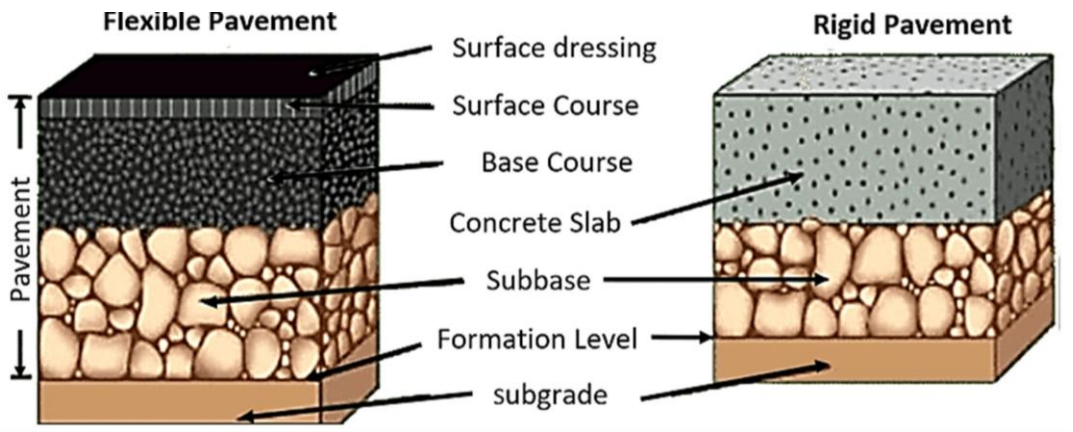
Proper road construction is essential to ensure longevity, safety, and cost-effectiveness. Roads that are poorly constructed degrade quickly, leading to increased maintenance costs, safety hazards, and traffic congestion. Selecting the right pavement type and following standardized construction practices can significantly enhance the durability of roads.

Types of Pavements

Road pavements are broadly classified into two types: flexible and rigid pavements. The choice between these depends on factors such as traffic volume, environmental conditions, maintenance requirements, and budget considerations.

Flexible pavements consist of multiple layers designed to distribute traffic loads gradually to the subgrade. The topmost layer, known as the surface course, is typically composed of asphalt, providing a smooth and durable riding surface. Beneath it lies the base course, which ensures structural support and load distribution, followed by the sub-base course that further stabilizes the pavement structure while also serving as the primary drainage layer. The lowest layer, the subgrade, consists of compacted soil that forms the foundation of the pavement. Flexible pavements are advantageous due to their adaptability to temperature variations and minor ground settlements. However, they require periodic maintenance, including resurfacing, to maintain their performance.

Rigid pavements, on the other hand, are constructed using concrete slabs and are known for their higher structural strength. Unlike flexible pavements, rigid pavements distribute loads more efficiently due to the stiffness of the concrete surface. They typically consist of a concrete slab resting on a base course, with the subgrade serving as the foundational layer. The sub-base in rigid pavements functions as a drainage layer, preventing water accumulation and protecting against subgrade erosion. Rigid pavements are preferred for high-traffic areas, highways, and industrial roads where longevity is crucial. They require less-frequent maintenance compared to flexible pavements, but the initial construction cost is significantly higher. Additionally, rigid pavements are prone to cracking if not properly designed with expansion joints to accommodate thermal movements.



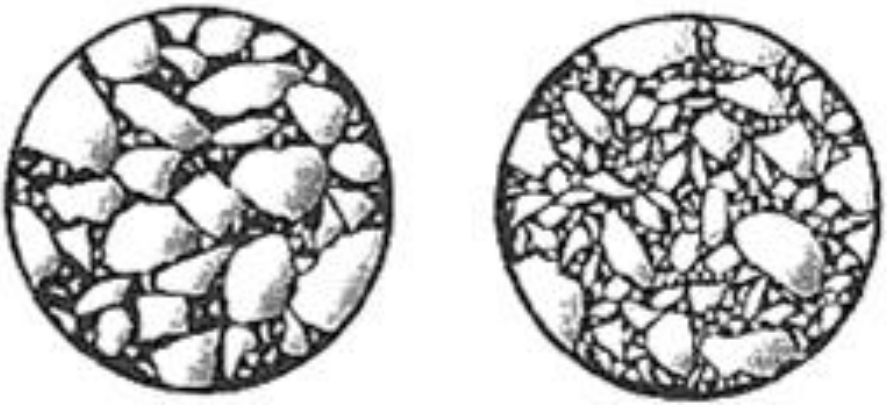
Layers of Rigid and Flexible Pavements
Source: Engineering Learn

Stone Matrix Asphalt

Stone Matrix Asphalt (SMA) is a high-performance asphalt mixture that offers superior durability and resistance to rutting, making it an ideal choice for high-traffic roads, highways, and urban corridors. Unlike conventional asphalt, SMA has a higher proportion of coarse aggregates bound together with a rich mastic of asphalt binder, fibres, and stabilizers, which enhances its structural integrity and longevity.

SMA is particularly beneficial in regions with heavy rainfall and high temperatures where conventional asphalt is prone to rapid deterioration. The mix design improves resistance to moisture-induced damage and oxidation, ensuring a prolonged service life. While the initial construction cost of SMA is approximately 10-15% higher than traditional asphalt, its longer lifespan and reduced maintenance requirements make it a cost-effective solution in the long run. Proper training and expertise are essential for its correct implementation, as the mix design and compaction process require precision to maximize performance.

The use of SMA significantly reduces road noise, enhances skid resistance, and minimizes reflective cracking, making it a preferred choice for expressways and urban roads. However, due to its specialized composition, availability of high-quality aggregates and stabilizing additives must be ensured before selection. Agencies adopting SMA should enforce strict quality control measures to achieve the desired performance standards.



Stone Matrix Asphalt (SMA)

Conventional Hot Mix Asphalt

Structure of aggregates of mixture SMA and conventional hot mix asphalt
Source: Analysis of use of natural fibers and asphalt rubber binder in discontinuous asphalt mixtures, Oda 2012

3. ENGINEERING

Road Pavement Selection

Selecting the appropriate pavement type depends on various factors, including traffic intensity, climatic conditions, maintenance considerations, and cost implications. The following guidelines help determine when to use flexible pavement, rigid pavement, or Stone Matrix Asphalt (SMA):

- **Flexible Pavements:** These are best suited for roads with moderate to high traffic volume that require ease of maintenance. They are ideal for urban and rural roads where minor settlements are expected. Flexible pavements are also recommended in areas where construction speed is a priority since they can be laid and opened to traffic relatively quickly. However, they require frequent resurfacing and periodic maintenance.
- **Rigid Pavements:** These are recommended for roads subjected to heavy traffic loads, such as highways, industrial zones, and airport runways. They are highly durable and have lower maintenance needs over their lifespan. Rigid pavements are preferred in areas where long-term investments in infrastructure are prioritized over short-term costs. However, their higher initial construction cost and longer curing time make them less suitable for projects requiring quick deployment.
- **Stone Matrix Asphalt (SMA):** These are ideal for high-traffic corridors, expressways, and areas with extreme weather conditions. SMA is particularly beneficial where superior resistance to rutting, moisture damage, and cracking is required. It is a suitable alternative to conventional asphalt in regions experiencing heavy rainfall or high temperatures. While SMA has a higher initial cost than traditional asphalt, its extended lifespan and reduced maintenance make it a cost-effective choice in the long run.

Factor	Flexible Pavement	Rigid Pavement	Stone Matrix Asphalt
Traffic Suitability	Suitable for low to moderate traffic roads	Best for high-traffic areas	Designed for heavy traffic and high-stress areas
Resistance to Rutting	Prone to rutting under high temperatures and heavy loads	No rutting but can develop cracks over time	Excellent rutting resistance due to stone skeleton structure
Construction Time	Faster construction; can be opened to traffic quickly	Requires longer curing time before use	Similar to flexible pavement but needs additional compaction effort
Maintenance & Repairs	Frequent maintenance (resurfacing, pothole repair)	Low maintenance but costly repairs (slab replacement)	Requires minimal maintenance due to high durability
Cost	Lower initial cost but higher maintenance cost over time	High initial cost but cost-effective in the long run.	Higher cost than conventional asphalt due to specialized materials
Best Used For	Urban and suburban roads, rural highways	Expressways, industrial roads, and airport runways	High-traffic highways, intersections, and bus lanes

3. ENGINEERING

Material Selection and Conformity

Material selection plays a critical role in pavement performance and longevity. For flexible pavements, high-quality asphalt and well-graded aggregates should be used to ensure durability. The asphalt binder should conform to design standards and be selected based on climatic conditions to resist temperature-induced damage such as rutting and cracking. Aggregates should be strong, durable, and properly graded to achieve optimal compaction and load distribution.

For rigid pavements, concrete mix design should be optimized to achieve the required compressive strength and durability. Portland cement concrete (PCC) should meet industry standards for strength, workability, and resistance to environmental conditions. Proper curing techniques must be followed to prevent early-age shrinkage and cracking. The reinforcement, if required, should conform to relevant specifications to enhance load-carrying capacity and resistance to fatigue.

A comparison between the two pavement types highlights their distinct advantages and limitations. Flexible pavements are cost-effective initially and provide a comfortable ride due to their ability to absorb minor deformations. However, their shorter lifespan and higher maintenance costs can make them less economical in the long run. Rigid pavements, while expensive to construct, offer a durable solution with lower maintenance needs, making them suitable for roads with heavy vehicular loads and long-term infrastructure planning.

Selecting the appropriate pavement type is crucial for ensuring efficient road infrastructure. Engineers must assess factors such as traffic patterns, climatic conditions, and lifecycle costs before making a decision. By understanding the strengths and weaknesses of flexible and rigid pavements, road authorities can implement construction strategies that enhance durability, safety, and cost efficiency.

Milling Process and Surface Preparation

Milling is an essential step in road rehabilitation that involves the controlled removal of existing asphalt layers before laying a new pavement surface. The primary objectives of milling are to restore proper surface levels, improve adhesion of new asphalt, and eliminate aged or deteriorated layers that may cause premature failure. Milling prevents the continuous increase in road levels, which can lead to drainage problems and conflicts with existing infrastructure, such as kerbs and utility lines.

Asphalt milling

The milling process is carried out using specialized machines equipped with rotating drums fitted with carbide-tipped cutting teeth. These machines grind and remove the asphalt surface to a specified depth, after which the reclaimed asphalt pavement is collected for potential reuse in future asphalt mixes, making the process cost-effective and environmentally sustainable. Once milling is completed, the surface is swept clean to remove any residual dust and debris, ensuring optimal bonding between the new asphalt layer and the underlying surface.

Proper milling enhances pavement longevity by providing a smooth and uniform surface, preventing uneven settlements and cracks. It restores proper drainage by eliminating ruts and depressions, reducing the likelihood of water accumulation that can weaken the pavement structure. Additionally, milling allows precise control of pavement thickness, minimizing material wastage and optimizing resource use. Quality control during milling involves monitoring the depth of removal, ensuring surface cleanliness, and inspecting the underlying base layer for any required repairs before resurfacing.

Timing and Curing

Proper timing and curing of road construction are essential to ensuring the structural integrity, longevity, and overall performance of pavements. The timing of construction activities significantly impacts the quality of the road, while the curing process plays a critical role in allowing the pavement to achieve its designed strength and durability. Current industry practices often favour night-time asphalting to minimize traffic disruptions; however, this approach can limit the effectiveness of cooling, quality inspection, and the ability to perform thorough quality control. To overcome this limitation, it is recommended to shift to daytime asphalting. This approach allows for better temperature management, more thorough quality checks, and enhanced coordination with regulatory authorities. Furthermore, asphalt deliveries should be scheduled to arrive before morning peak hours to minimize traffic congestion and ensure smooth construction operations. In addition to these factors, weather conditions such as heavy rainfall or extreme temperatures must also be carefully considered when planning construction schedules, as they can negatively impact the quality and performance of the pavement if not accounted for properly.

Failures of asphalt surface
Source: Ahmad and Khawaja (2018)

When it comes to curing, asphalt pavements require controlled cooling to achieve the appropriate stiffness and strength necessary for long-term durability. Rapid cooling can lead to thermal cracking, while inadequate cooling before opening the pavement to traffic can cause premature deformation under load. Asphalt layers should be allowed to cool gradually, reaching a temperature of around 30°C before being opened to traffic (which would ideally take around 4 hours), ensuring that the pavement is sufficiently strong and resistant to stress. Concrete pavements, on the other hand, require proper curing methods to ensure the development of adequate strength and durability. To prevent issues such as premature drying and shrinkage cracks, methods such as water curing, membrane curing, and use of curing compounds are necessary. These techniques help maintain moisture levels within the concrete, which is essential for the hydration process and for minimizing the risk of cracks. The curing period for concrete pavements typically ranges from 7 to 28 days, depending on factors such as the concrete mix design and environmental conditions during the curing process.

The importance of adequate curing cannot be overstated, as it significantly enhances the pavement's resistance to fatigue, moisture damage, and variations in temperature. Both asphalt and concrete pavements benefit from proper curing, which not only improves their longevity but also ensures better performance under different environmental conditions. By adhering to optimal timing and curing practices, road construction projects can ensure that the pavements are more durable, require less long-term maintenance, and perform better throughout their service life, ultimately contributing to safer and more sustainable infrastructure.

Traffic police is recommended to play a vital role in this process by ensuring that road construction sites are safely managed and that the flow of traffic is regulated to minimize disruptions. Their presence is particularly crucial when the curing process involves temporary closures or detours. Effective coordination between construction teams, traffic police, and local authorities is essential for achieving a successful road construction project while maintaining safety and operational efficiency.

Rehabilitation and Maintenance

Pothole patchwork

3. ENGINEERING

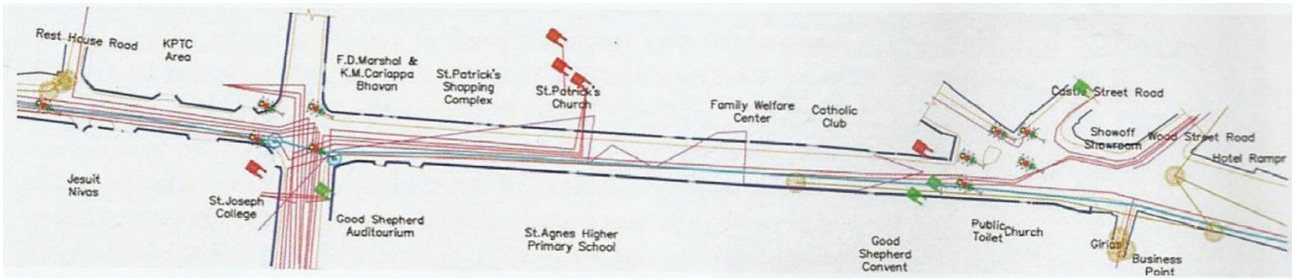
Designing, Engineering, and Implementing Sub-Surface Utilities Including Stormwater Drains, Sewage, Water, Optical Fiber Cable, and Electric

What is Utility Design?

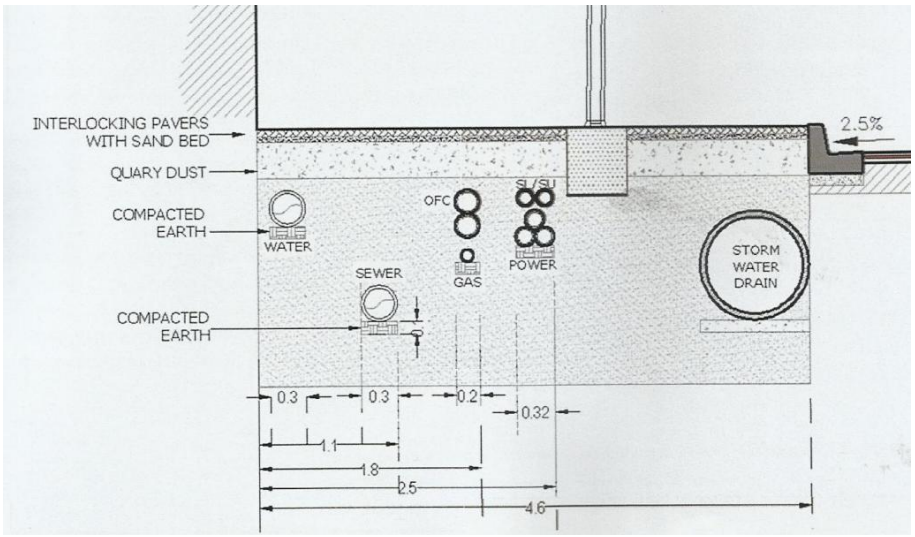
Utility design refers to the comprehensive planning of subsurface utilities in a manner that fulfils requirements, as well allows for easy access and modification. Utility planning during comprehensive development of roads prevents excessive digging of roads for utility repair and expansion.

Utility design requires coordination between various stakeholder agencies such as BWSSB and BESCOM. Design should consider both current and future needs and align utilities in a manner that allows for easy access and upgrades with minimal disruption to the surface.

Storm water management, including the proper cambering of streets, filtration and percolation elements such as bioswales, and stormwater drains, allows for the rapid and efficient drainage of water from Bengaluru's streets.



Reference Utility Map
Source: Tender SURE Vol.1



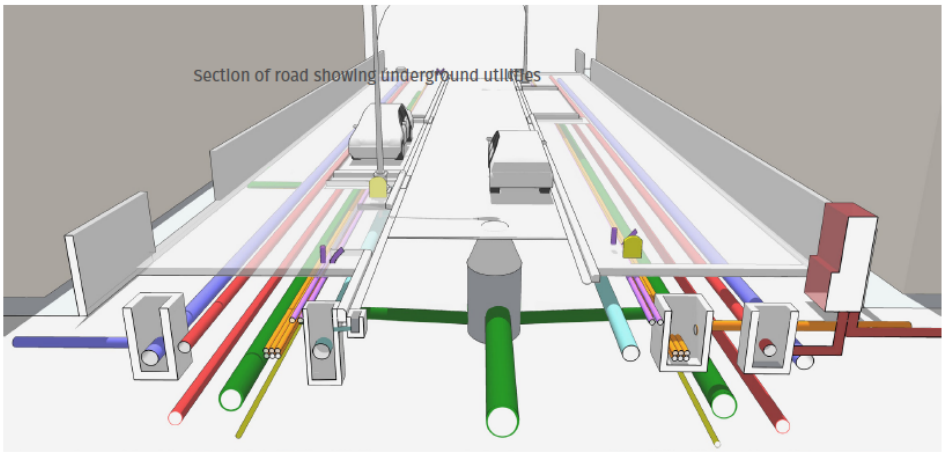
Reference Utilities Section
Source: Tender SURE Vol.1

Utilities

Utilities should be systematically arranged and mapped to facilitate easy modification, replacement, maintenance, and future expansion. Utilities should be mapped both before road development and after utility relocation to ensure accurate planning and coordination.

Utilities should be shifted at the time of comprehensive development to prevent unnecessary digging and damage to pavements.

MARCS application for digging by external stakeholders to access utilities should be highly restrictive and for emergency reasons only. Ideally, digging should be minimized, and utility shifting should be carried out during the comprehensive road development process. Newly added utility lines should be mapped in a centralized Dynamic Dashboard under ICCC to enhance coordination and tracking.



Category	Water	Electricity		Street Lights & other fixtures		Stormwater
Utility Pipe	Main	Low-tension	High-tension	Side lines	At median	Main
Duct Material	MS/DIP	HDPE DWC	RCC-NP3	HDPE	HDPE	RCC-NP3
Duct size (dia)	0.15m-0.3m	0.15m-0.3m	0.3m-0.45m	0.1m-0.2m 0.3m	0.3m 0.3m	0.5m-1.2m 0.5m-1m
Service laying depth	1m-6m	0.6m-1m	1.5m-2m			

Category	Sewage		Telecommunications		Private connections	Additional ducts
Utility Pipe	Rider sewer	Trunk sewer (under median)	Copper cables	Optic fibres OFC	For each utility	Future additions
Duct Material	RCC Hume Pipe	RCC Hume Pipe	HDPE	HDPE	PVC/HDPE	HDPE
Duct size (dia)	0.3m-0.45m	0.5m-1m	0.1m-0.3m	0.1m-0.3m	0.1m	0.15m
Service laying depth		More than 1.5m	0.6m-1m if directly laid 1m-2m if laid in ducts			

Distance between electric cables & OFC
Vertical - 1m
Horizontal - 1m

Distance between electric cables & water supply lines HT/LT
Vertical - 1m
Horizontal - 1m

Source: Healthy Streets Design Workbook, MoHUA

Utility Placement

To the left is an example of utility placement that provides adequate space to maintain, expand, and access a variety of utilities including water, sewage, electricity, storm water, OFC and more.

Above ground and underground chambers are placed to access utilities without needing any digging or disruption to the carriageway.

Local utility design should be site-specific and consider the context and needs of the area.

04 OPERATIONS AND MAINTENANCE

4. OPERATION AND MAINTENANCE

Defect Liability Period (DLP) and Maintenance Manual

To ensure accountability and long-term sustainability of road infrastructure projects, a clear and well-defined scope of work must be included in the Request for Proposal (RFP) for contractors during this DLP. This scope should outline the following:

- Duration of the DLP – Specifying the period during which the contractor is responsible for repairs and defect rectification.
- Types of Defects Covered – Including surface deterioration, sinkholes, structural failures, pavement damages, and drainage blockages.
- Maintenance Responsibilities – Clearly defining the contractor's role in routine inspections, emergency repairs, and defect rectification.
- Reporting and Documentation – Outlining requirements for submitting as-built drawings and post-implementation report.
- Penalties for Non-Compliance – Specifying consequences for contractors who fail to adhere to maintenance obligations.

Submission of As-Built Drawings and Maintenance Manual

At the completion of any project, the contractor must submit the following:

1. As-Built Drawings – Final construction plans reflecting any modifications made during implementation.
2. Post-Implementation Report – A detailed document including the following:
    - Materials used and quality certifications
    - Road health status at the time of project handover
    - Maintenance strategy and expected wear-and-tear observations
3. Maintenance Manual – A comprehensive guide covering the following:
    - Standard maintenance protocols
    - Frequency of inspections required
    - Instructions for preventive upkeep

Budget Allocation for Documentation

A **dedicated budget** should be allocated for these documentation activities. Failure to comply shall result in the contractor receiving an official **notice of non-compliance**, which will be formally documented.

4. OPERATION AND MAINTENANCE

Standardized Project Completion Checklist

To ensure systematic project closure, the committee recommends the implementation of a Standardized Project Completion Checklist to be filled out by the Assistant Executive Engineer (AEE) or Executive Engineer (EE) at the end of each project. The checklist should include the following components:

- Verification of completed works as per the approved design.
- Compliance with material quality standards.
- Proper drainage and stormwater channel implementation.
- Adequate pedestrian and vehicular safety measures.
- Submission of all necessary documentation (as-built drawings, maintenance manual, and post-implementation report).

This checklist will serve as an official approval mechanism before final project sign-off and financial closure.

Non-Compliance and Contractor Performance Evaluation:

To enhance accountability, a **contractor performance evaluation system** will be introduced.

Penalties for Non-Compliance: Failure to submit required documentation (as-built drawings, post-implementation report, and maintenance manual) will result in a **reduction of qualification points** in future BBMP project bids.

Issuance of Memos for Continued Violations:

First Memo – Official warning for non-compliance.
Second Memo – Deduction of qualification points for future tenders.
Third Memo – Blacklisting of the contractor from BBMP projects.

These measures will ensure that only **reliable and responsible contractors** are engaged for future infrastructure projects, thereby improving long-term road quality and sustainability.

The proposed framework for the Defect Liability Period (DLP) and Maintenance Manual aims to streamline project handover processes, improve contractor accountability, and enhance long-term infrastructure maintenance. By enforcing standardized completion protocols and stringent compliance measures, this initiative will contribute to sustainable, high-quality urban infrastructure for Bengaluru.

4. OPERATION AND MAINTENANCE

Establishment of a Dedicated Road Maintenance Cell

To ensure the systematic upkeep of Bengaluru's road infrastructure, the committee recommends the establishment of a dedicated Road Maintenance Cell within BBMP. This cell should have structured representation from: BBMP Engineering and Maintenance Divisions, Bangalore Traffic Police (BTP), BWSSB (Bangalore Water Supply and Sewerage Board), BESCOM (Bangalore Electricity Supply Company Limited), Telecommunication Service Providers, Urban Development Authorities, Citizen Representative Groups (RWAs, Advocacy Groups, NGOs, etc.)

This cell shall function as a **centralized authority** for road upkeep, responsible for coordinating maintenance works, conducting quality inspections, and ensuring public engagement in road management. Primary Functions of the Road Maintenance Cell shall include the following:

- Routine and Need-Based Inspections – Conducting monthly and quarterly audits to assess road conditions and detect early-stage defects such as potholes, cracks, and surface deterioration.
- Emergency Response Mechanism – Setting up a dedicated helpline and digital grievance redressal system for the public to report road-related issues, ensuring timely interventions.
- Maintenance Coordination – Facilitating seamless coordination between BBMP, traffic police, utility agencies, and contractors to avoid delays in repair and reconstruction.
- Stakeholder Engagement – Organizing periodic meetings with citizen groups, local leaders, and urban experts to incorporate community feedback into road maintenance strategies.

Annual Road Infrastructure Assessment

To ensure proactive road maintenance, the committee recommends conducting a comprehensive annual assessment of Bengaluru's road network. This assessment will facilitate early defect detection and enable the planning of effective preventive maintenance strategies.

Assessment Methodology:

- **Visual Inspections and Digital Surveys** – Executive Engineers shall deploy regular site inspections for road deformations or maintenance needs of footpaths, utilities, carriageway pavement, etc. Technology that can be utilized in the long run includes artificial intelligence-powered inspection tools, drones, and GIS mapping to assess road conditions.
- **Defect Classification System** – Road defects are categorized based on severity and urgency, ensuring prioritized maintenance based on real-time data.
- **Public Reporting Mechanism** – A citizen-reporting platform is integrated to allow residents to submit real-time complaints with geotagged locations. Integrate technology to geolocate the reported instances to be later showcased at ICCC dashboard allowing for mapping of repetitive issues allowing for better action in the long run in cases of repetitive reporting from one region.
- **Structural Integrity Tests** – These include conducting load-bearing capacity tests, material testing, and subsoil stability assessments, particularly for white-topped roads and flyovers.

The results of this annual assessment should be publicly available, ensuring transparency and accountability in road maintenance.

4. OPERATION AND MAINTENANCE

Advanced Road Maintenance Model

A. Single-Agency Responsibility for Road Maintenance

The committee recommends assigning a single agency per ward responsible for the following:

- Regular inspection, repair, and upkeep of roads, footpaths, and intersections.
- Cleaning and waste disposal along all road corridors.
- Reporting and addressing of drainage-related issues.
- Coordination with civic agencies to prevent excavation damages.

This agency should be monitored through performance-based contracts, ensuring accountability and high service standards.

B. Comprehensive Stormwater Drain Maintenance Strategy

- Pre-Monsoon Desilting Operations – All drains must be cleared before the rainy season to prevent waterlogging.
- Post-Monsoon Cleaning and Damage Repair – A second phase of drain desilting should be conducted after the monsoons to remove silt accumulation.
- GIS Mapping of Stormwater Drainage Networks – A digitized database should be created to monitor drain health and track flood-prone zones.

C. Deployment of Mechanical Sweepers for Road Cleaning

- Each ward shall have independent mechanical sweepers for different types of streets.
- Regular maintenance of these machines will be mandatory, with proper budget allocation for operations and repairs.
- Ensure trained personnel operate the machines with periodic efficiency checks.

Engagement of Private Agencies for Post-DLP

After the **defect liability period (DLP)** of newly constructed or repaired roads, private agencies should be engaged for continued maintenance. Detailed scope of work shall be defined for third-party private agencies, including the following:

- Routine Road Repairs – Addressing cracks, potholes, and wear-and-tear.
- Drainage and Footpath Upkeep – Ensuring stormwater drains and sidewalks remain functional.
- Street Furniture and Signage Maintenance – Keeping pedestrian zones, crossings, and street signs in optimal condition.

Performance-based contracts should be introduced, ensuring agencies meet maintenance benchmarks before payment disbursal.

4. OPERATION AND MAINTENANCE

Public Engagement and Digital Governance

A. Citizen Involvement in Road Maintenance

- Launch of a BBMP Road Watch App – A mobile-based complaint registration system that allows citizens to report road defects with geo-tagged images.
- Formation of Ward-Level Road Committees – Resident welfare associations (RWAs), NGOs, and local institutions to participate in road monitoring and feedback collection.

B. Digital Dashboard for Transparency

- A real-time road maintenance dashboard displaying the following:
    - Active and completed road repair works.
    - Contractor details and project timelines.
    - Budget allocation and spending reports.
- Citizens should be able to track progress and receive updates on reported issues.

Budget Allocation and Sustainable Road Maintenance

To ensure the long-term sustainability of road maintenance, the committee recommends the following

- Annual Budget Allocation for Maintenance and Emergency Repairs – A dedicated fund for proactive maintenance rather than reactive patchwork.
- Incorporation of Sustainable Road Repair Techniques – Use of recycled materials, cold-mix asphalt, and permeable pavements to enhance road lifespan.
- PPP Model for Road Maintenance – Partnership with private entities and CSR initiatives to co-fund and maintain roads under long-term contracts on a need basis

Monitoring and Evaluation Framework

A dedicated monitoring & evaluation (M&E) team within the Road Maintenance Cell should be responsible for the following:

- Third-Party Quality Audits – Conducting independent road audits every six months.
- Contractor Performance Ratings – Assessing contractor efficiency and blacklisting defaulters.
- Quarterly Progress Reports – Publishing periodic reports on BBMP's official portal for public access.

The proposed Road Maintenance Cell will serve as a centralized, accountable, and data-driven unit, ensuring systematic upkeep of Bengaluru's roads. With a focus on technology adoption, stakeholder engagement, and sustainable practices, this initiative will significantly improve road quality, reduce maintenance costs, and enhance public safety.

5. CONCLUSION

The Committee has undertaken a comprehensive and methodical review of the landscape of road development and maintenance in Bengaluru. This process involved extensive consultations with key stakeholders within and outside BBMP, ensuring a holistic understanding of the challenges and opportunities in urban infrastructure development. Additionally, a thorough examination of relevant literature was conducted, including the 144-page manual authored by K.N. Shivashankara Rao, Chief Engineer (Retd), PWD, GoK and Member, TAC, BBMP on BBMP Roads (2009), as well as established guidelines such as Tender SURE, HDC Design Manual, and IRC standards, which are widely recognized as benchmarks in road design and execution.

While some of these systemic issues extend beyond the scope of this Committee, it is imperative to institutionalize structured capacity-building initiatives. Training and professional development for BBMP engineers should not be treated as a one-time compliance exercise, but rather as a regular and structured intervention, akin to the continuous training frameworks followed by IAS and IPS cadres.

This document captures critical aspects of **planning, design, execution,** and **maintenance** within the BBMP ecosystem. Some recommendations focus on process optimizations, while others provide technical guidance rooted in best practices, many of which have already been successfully implemented in Bengaluru.

It is our sincere hope that this document serves as a practical and empowering resource for **BBMP Engineers**, **Contractors**, **DPR & Design Consultants**, and **Support Staff**, enabling them to make informed, data-driven decisions at every stage of project execution. More importantly, we aspire for this to instill a sense of professional pride, ensuring that their work is recognized and valued by citizens and industry experts alike.

This document is not intended to be a definitive or final authority on these subjects. Like any evolving technical manual, it must be continuously refined and updated based on real-world implementation experiences and lessons learned on the ground. We strongly recommend that the principles and recommendations outlined herein be tested during the upcoming 400 km road improvement project, with revisions incorporated based on empirical feedback and on-site challenges.

The committee suggests that these recommendations be applied to a pilot of 100 km under the supervision of the committee. This can be called "Namma Raste 100", to further improve and validate the SOP on ground.

Finally, we extend our sincere gratitude to all individuals and organizations who contributed to this initiative. We express our deep appreciation to **BBMP Chief Commissioner Shri. Tushar Giri Nath, IAS** for his unwavering support and leadership in making this effort a reality.

6. GLOSSARY

Access - Approach to a plot or a building from a road or street.
Accessibility - The ability for all people, including people with impaired mobility and of all ages, to physically reach their desired destinations, services and/or activities with ease. See also Universal accessibility.
Ambulant Disabled - People with disabilities that limit their ability to walk, but who don't use wheelchairs regularly.
Arterial Road – A high-capacity urban road whose primary function is to deliver traffic from one hub to another.
Assistant Executive Engineer (AEE) – A mid-level engineer ranked below an executive engineer, often directly supervising projects on site.
Asphalting – The laying of road using a composition of various layers composed of bitumen, aggregate, binders, gravel and compressed earth.
At-Grade - Being on the same level.
Audio Beeper – A devise used to aid people with visual impairments.
Bangalore Electricity Supply Company Limited (BESCOM) - The Bengaluru Zone of Karnataka Power Transmission Corporation Limited, the sole power transmission and distribution company in the state of Karnataka.
Bangalore Water Supply and Sewerage Board (BWSSB) – The governmental agency responsible for sewage disposal and water supply in Bengaluru
Base Course (BC) – The foundation layer of a road usually composed of sand, gravel or crushed stone.
Bengaluru Metro Rail Corporation Limited (BMRCL) – A joint venture between Government of Karnataka and Government of India that operates the city's rail rapid transit system.
Bengaluru Solid Waste Management Limited (BSWML) – A government-owned company that executes solid waste management projects on behalf of BBMP.
Bengaluru Traffic Police (BTP) – A specialized unit of the Bangalore City Police, responsible for overseeing and enforcing traffic safety compliance in Bengaluru.
Bicycle - A person using a non-motorized, human-powered wheeled vehicle for travel (with the exception of wheelchairs).
Bicycle Boulevard – A low-speed street that's designed for bicycles to share with motor vehicles.
Bicycle Track - A path separated from motorized traffic and dedicated to cycling or shared with pedestrians or other nonmotorized users.
Bioswale – A vegetated depression running alongside the road into which storm water is directed. This landscape element is designed to remove debris and pollution out of surface runoff water.
Bollard - A sturdy, short, vertical post installed to control road traffic and designed to prevent motorized vehicles from entering areas reserved for pedestrians.
Bruhat Bengaluru Mahangara Palike (BBMP) – The administrative body responsible for civic amenities and some infrastructural assets in Bengaluru.
Building Line - A designated line drawn along the edge of a municipality's footpath beyond which a building must not extend into the street.
Buffer - A safety area between adjoining land uses or developments created to mitigate the impact of one over the other, such as separating traffic flow from pedestrians with a transitional recovery space.
Bulb-out – Also known as kerb extension. A traffic calming measure used by extending the footpath to reduce a distance pedestrians have to cross a street. It facilitates approaching drivers to see each other when parked vehicles in a parking lane block visibility.
Bus Lane – A special lane on a road that is only used by buses. Emergency vehicles are often permitted to use bus lanes as well.
Cat Eye – Is a retro-reflective safety device used in road marking, usually as raised pavement markers.
Catchment – An area from which a city, service or institution attracts a population that uses its services.
Cambering - The slight downward slope of a road from center to the edges to help water drain rapidly.
Carriageway - Part of a road intended primarily for vehicles movement rather than for pedestrians.
Chief Engineer (CE) – A senior engineer who supervises a large number of projects across geographic zones at a high-level.
Clear Walking Zone - Also known as Pedestrian zone, it is the space required for 4 persons or 1 wheelchair + 2 persons to traverse comfortably. This provides pedestrians with a clear unobstructed walking zone to use.
Collector Road - It is a distributor road that is a low-to-moderate-capacity road. It serves to move traffic from local streets to arterial roads and provide access to residential properties.
Compact Intersections - Designed junctions where every inch of space is accounted for as either required carriageway (based on turning radii, etc.) or pedestrian space. The rational and compact design of junctions reduces pedestrian conflicts and improves vehicular flow by reducing the ambiguity, size, and crossing distances present.
Conservancy Lane – A narrow lane that runs parallel to larger roads in residential areas. Typically found in older planned residential areas of Bengaluru such as Basavanagudi and Malleswaram.
Corporate Social Responsibility (CSR) – Private business contributions towards societal goals.
Crossings - A designated crosswalk for pedestrians to cross a road or street.

6. GLOSSARY

Curing – The process of maintaining temperature and moisture in cement after application to maximize strength and durability.
Defect Liability Period (DLP) - The period in which contractors are liable for any defects that appear in the completed work.
Dense Bituminous Concrete (DBC) – Also known as dense bituminous macadam, it is a dense mixture of aggregates, bitumen and filler often used as the base course on roadways.
Directorate of Urban Land Transport (DULT) – Set up the Government of Karnataka with the objective of coordinating planning and implementation of urban transport projects and programs.
Detailed Project Report (DPR) – A document that outlines a project's technical, financial, and operational aspects.
Differently-Abled – A lack of normal functioning of physical, mental or psychological processes.
Engineer-in-Chief (EIC) – The senior-most engineer at BBMP. Chief engineers report directly to EIC.
Feasibility - Capable of being accomplished with a reasonable amount of effort, cost, or other hardship.
Filtration – The process of removing impurities from water.
Flexible Pavement – A road surface comprising of layers of aggregate and bitumen (asphalt) that can bend to due to traffic loads.
Flush – Level with the surrounding area.
Foot-Over Bridge (FOB) - Is a bridge designed for pedestrians and in some cases cyclists, and does not cater to vehicular traffic.
Frontage Zone - An area adjoining a building or property line that provides additional space to ensure conflict free movement for pedestrians.
Gas Authority of India Ltd (GAIL) – A Government of India owned energy corporation primarily focusing on the transmission and distribution of natural gas.
Geographic Information System – A computer system that analyses and displays geographically referenced information.
Grate - A framework of lattice, grid, or bars that prevent large objects from falling through a drainage inlet but permits water to flow through the slots.
High-Density Corridors (HDC) - Key roads extending from Bengaluru's city center to surrounding regions and urban areas. The corridors have witnessed huge amounts of growth in the last few decades.
HRPC (High Raised Pedestrian Crossing) - A zebra-crossing elevated to the level of the footpath, thus functioning as a safe crossing and a speed hump to reduce vehicle speeds and enhance pedestrian visibility. Also known as 'Table-Top Crossing'.
Indian Road Congress (IRC) - The apex body of highway engineers in India. The organization publishes manuals/ guidelines whose codes act as the blueprint for road design in India.
Integrated Command and Control Centre (ICCC) - a decision support system that integrates data from various departments to improve city planning and management
Intermediate Public Transport (IPT) - Also known as paratransit, a flexible, informal transportation system that connects people to public transit and other areas of a city.
Karnataka Power Transmission Corporation Limited (KPTCL) – The sole electricity transmission and distribution authority in the state of Karnataka.
Landscape - Plantings, configuration and maintenance of trees, ground cover, shrubs and other plant material, natural decorative and structural features, earth patterning and bedding materials, and other similar site improvements that serve an aesthetic, functional or sustainable purpose.
Microsurfacing - The application of a thin, slurry-like mixture of polymer-modified asphalt emulsion, aggregate, water, and additives over the existing pavement to help restore surface texture, improve skid resistance, and fill minor cracks, providing an effective solution for roads in need of rejuvenation.
Milling - The process of removing the top layer of asphalt from a road
Multi-Agency Road Cutting Co-ordination System (MARCS) - An online portal where government agencies submit requests for road digging permissions, usually to access utilities.
Multimodal - Refers to the availability of transportation options within a system or corridor.
Multi-Utility Zone (MUZ) - The portion of the footpath that provides space for landscaping, seating, utility boxes, IPT stands, bus stops, signs, street vendors, dust bins and private property access ramps.
Median Extension/Protective Head - An extension of the median beyond the pedestrian crossing to protect pedestrians from turning vehicles, especially U-turn movements.
NCAP 20 - A BBMP program to improve air quality at 20 junctions using National Clean Air Program funds through greening and redesigning of junctions.
Network - A system of interconnecting streets.
Non-Motorized Transport (NMT) - Non-motorized Transport is human powered transportation, which includes walking, bicycling, and small-wheeled transport (cycle rickshaws, skates, skateboards, push scooters and hand carts) and wheelchair.
Non-Motorized Vehicles (NMV) - Pedal powered vehicles (cycle-rickshaws, bicycles)
Notice of Non-Compliance – A formal notification that someone or something has not met certain standards or requirements.
Optical Fiber Cable (OFC) – A cable similar to an electric cable carrying light, used for moving data for services such as internet.

6. GLOSSARY

Parallel Parking - Parking that is parallel to the kerb and path of travel.
Pedestrian - A person on foot or in a wheelchair.
Pedestrian Refuge Island - Secure areas in the middle of a junction for pedestrians to halt before crossing long distances. Creating these pause points reduces the risk of pedestrians coming into conflict with vehicles.
Percolation – The flow of fluids through porous materials
Percolation Pit - A percolation pit is a hole dug into the ground to capture rainwater and recharge groundwater.
Permeable Pavement - A paving system which allows rainfall to percolate into the soil. It can also aggregate in an underground storage reservoir where storm water is stored and filtrated in underlying subgrade or removed by an overflow drainage system.
Plaza - A community space that serves a variety of amenities to users including building tenants, visitors and members of the public. Plazas are a beneficial feature of a lively and active streetscape.
Pick-up and Drop-off Area - Designated area for passenger pick-up and drop-off.
Public-Private Partnership (PPP) – An agreement between a government and a private company to build, operate, or maintain public services and assets.
Public Space - A space that is open and accessible to people of all levels. Street and roads are public spaces, which typically include pavements, public squares, parks and beaches, etc.
Public Transport - It is a system of vehicles such as buses, trains and other forms of transport that are available to the public, operate at regular times on fixed routes and charge a set fare.
Ramp - A sloping surface joining two different levels as at the entrance or between floors of a building.
Recharge Well – A subsurface well that collects rainwater and directs it into the ground to replenish groundwater levels.
Reclaimed Asphalt Pavement – A material made from old asphalt that's been crushed and reprocessed.
Refuge Island - An area in a junction or crossing where pedestrians may wait protected from motor vehicles.
Request for Proposal (RFP) – A document used to ask potential vendors for proposals to meet a specific need or project.
Right-of-Way (ROW) – The legal right to pass along public property such as a thoroughfare. A street ROW is the width between property boundaries on one side to property boundaries on the other. A footpath is a right of way that can only be used by pedestrians.
Rigid Pavement - Also known as concrete pavement, is a strong, durable road surface made of concrete slabs. It's often used for highways and high-traffic areas.
Road - Any highway, street, lane, pathway, alley, stairway, passageway, carriageway, footway, square, place or bridge, whether a thoroughfare or not, over which the public have a right of passage or have uninterrupted access for a specified period. It includes bunds, channels, ditches, storm-water drains, culverts, sidewalks, traffic islands, roadside trees and hedges, retaining walls, fences, barriers and railings within the street lines.
Road Cross-Section - A vertical slice of a road that shows the road's structure from the front.
Rumble Strips - A series of strips placed before a crossing or intersection to reduce vehicle speeds. The number of strips, the number of sets, and the distances for placement are prescribed by relevant IRC codes.
Safe Access to Schools (SATS) - A WRI India initiative in Bengaluru to introduce safety elements along roads leading to schools to improve their safety specifically for school children.
School Access Zone (SAZ) - The roads leading to every entrance of a school, extending 100 m on either side of the school entrances.
School Management Committee (SMC) - The elected representatives of the local authority, parents or guardians of children admitted in schools and residents within the SAZ.
School Proximal Zone (SPZ) – All roads within the applicable zone radius of a school (100m), excluding the SAZ.
Setback - The minimum distance at which a structure must be set back from a street or road, or any other place which is deemed to need protection.
Shared Street - Often referred to as a “pedestrian-priority street,” a shared street is a low-speed, typically kerb-less road designed as a single surface, shared among pedestrians, bicyclists, and low-speed motor vehicles.
Shoulder - An extended portion on the left side of the carriageway by the verge of the road. It serves as an emergency stopping lane.
Shy-Away Zone - Space left between vehicles or pedestrians as they pass each other. The amount of shy distance required for safety increases with speed.
Signage - The design or use of signs and symbols to communicate a message to a specific group or used for the purpose of advocacy.
Sinkhole – A depression in the ground that's caused by the collapse of the ground beneath it.
Slip Lane - A short road connecting a main road or a dual carriageway.
Slope – Also known as grade. Incline of a physical feature, landform or constructed line refers to the tangent of a surface to the horizontal. Zero indicates horizontality and a larger number indicates higher or steeper degree of gradient.
Speed Calming - Elements designed to reduce vehicle speeds, thereby decreasing the likelihood of conflicts and crashes.
Speed Hump - Undulations used for 10–15 mph speed zones. They are used on local streets where traffic needs to flow smoothly but at a slower speed. Playground and school zones often use these in traffic management.
Stakeholders - Groups or individuals that have an interest/stake in the outcome of the planning or development of a project.

6. GLOSSARY

Stone Matrix Asphalt (SMA) – Also known as stone mastic asphalt, is a durable, rut-resistant asphalt mixture that's used on highways and other heavily trafficked roads.
Stop Line – The line at which drivers are required to stop at a junction or crossing.
Stopping Distance - The distance a vehicle travels from the time the driver sees a hazard until the vehicle comes to a complete stop.
Storm Water – Water that flows from precipitation such as rain.
Storm Water Drain - Designed to drain excess rain and ground water from impervious surfaces such as paved streets, car parks, parking lots, footpaths, sidewalks, and roofs.
Street Furniture - Items of furnishing in outdoor landscaping such as benches, trash receptacle, signage, play equipment, etc.
Street Parking - When vehicles are parked on the street, along with the sidewalk or anywhere on the street. Users of on-street parking are usually casual users who use the space for a short period of time.
Streetscape - A view or scene of streets in a city. The visual elements of the street include the road, adjoining buildings, sidewalks, street furniture, trees and open spaces, etc.
Stroller - A chair on wheels, typically folding, in which a baby or young child can be pushed along
Sub-Arterial Road – A lower-level of road than an arterial road, whose responsibility is to carry vehicles from arterial roads to adjacent areas.
Sub-base Course (SBC) - It is the lowest point of a pavement structure - the underground level at which excavation ceases and construction starts. Sub-grade mostly comprises of compacted earth, except for permeable pavements where it must be kept non-compacted.
Suraksha75 - A BBMP initiative to redesign 75 junctions in the city to improve pedestrian safety.
Surface Course (SC) – The top layer in a roadway that protects the underlying layers from traffic and weather while providing an adequate amount of tire friction.
Sustainable - Sustainable development is the development that meets the needs of the present without compromising the ability of future generations to meet their own needs.
Tactile Paving – A textured surface that helps visually impaired people navigate safely.
Target Speed - The speed at which vehicles should operate on a thoroughfare in a specific context. It should be consistent with the level of multimodal activity generated by adjacent land uses to provide both mobility for motor vehicles and a safe environment for pedestrians and bicyclists.
Tender SURE – Street design guidelines for urban roads including underground utilities, pedestrian infrastructure and operations & maintenance.
Tender SURE Lite – A simpler version of Tender SURE designed to tackle last-mile connectivity by improving footpath and drain conditions.
Thermoplastic Paint – A road marking paint. A hot melt kettle is used to heat it to 200°C then sprayed on the road surface as markings. The coating becomes a line after cooling.
Traffic - Pedestrians, ridden or herded animals, vehicles, bicycles, and other conveyances either singly or together while using any highway for purposes of travel.
Traffic Calming Elements - Deliberate slowing of traffic by using physical design and other measures to improve safety for motorists, pedestrians and cyclists. It encourages safer, more responsible driving and aims to potentially reduce traffic flow
Transit - Any type of transport shared by the public in large numbers, including bus, light rail, tram, or Metro.
Tree Grate - A grille installed at the base of a tree in a pavement. It allows free passage of air, water, and nutrients to the tree root but does not interfere with the foot traffic.
Trin Trin – A branding of cycling infrastructure provisions by DULT.
Turning Radius - The path that a vehicle takes during a turn.
Universal Accessibility - Universal accessibility is crucial to inclusivity. Design elements such as ramps designed with accessibility in mind that include slope ratios, width, tactile paving, etc.
Unobstructed – A clear path with horizontal and vertical passage.
Utilities - Crucial infrastructural components of street services located mostly underground. These service mains may include lines for electricity distribution, traffic/street lights, telecommunication, signal lights, cable television, fibre optics, natural gas, water supply, irrigation lines, storm drains, waste-water, sewerage pipes, etc.
Variable Message Sign (VMS) – A digital sign that displays information to drivers in real-time.
Vertical Clearance - Minimum unobstructed vertical passage along the pedestrian realm and travelled way.
Visual Impairment - Loss or partial loss of vision.
Vulnerable Users – People who are more likely to be injured or killed in a car accident.
Walkable - Streets and places designed or constructed to provide comfortable facilities for pedestrians that are safe and easy to cross for people of all ages and abilities.

6. GLOSSARY

Walkability - It is a measure of how friendly an area is to walking. It is related to walkable footpaths, proximity to transit facilities, air quality, accessible to work and social activities, safety from moving vehicles, lack of street crime, etc., while providing health, environmental, and economic benefits.
Ward Road - Also known as a local road, it is a road that serves a residential area and caters to local traffic.
Wayfinding - Ways in which people orient themselves in physical space and navigate from place to place.
Wayfinding Signage - Signs that help direct people from one point to another, or confirm their progress along a route. The message can be directional, confirmational, or informational.
Water Logging – When there is too much water on the road, which can be caused by heavy rainfall, poor drainage, or other factors. This can lead to traffic jams, road closures, and other problems.
Wheelchair – A chair mounted on wheels especially for the use of disabled persons.
White Topping - The surfacing of a road with cement instead of asphalt. Due to the difficulty in digging cement, white topping usually involves a relaying and rationalization of utilities, lighting, and provision of footpaths.

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8. ANNEXURE

1. Tender SURE, Volume 1
2. HDC (high density corridor) Design Standards Manual
3. SOP Committee Appointment Order
4. SOP Committee Meeting Notices

This document was prepared as an outcome of the discussions and recommendations under the SOP Committee formed by BBMP under the chairmanship of Engineer in Chief, BBMP - to evolve standard design and practices for road construction, development and maintenance of roads, preparation of the manual for road design and putting in place a Standard Operating Procedure (SOP) in BBMP limits. Based on the BBMP office order *BBMP/EIC/PR/654/2024-25 dated 19/11/2024.*

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February 2025


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MILLERS ROAD
MILLERS ROAD
ALI ASKER ROAD
EDWARD ROAD
CUNNINGHAM ROAD
QUEEN'S ROAD
SHIVAJI ROAD
CHICK BAZAAR ROAD
PARK ROAD
VENKATASWAMY NAIDU ROAD
MUSICAL FOUNTAIN ROAD
RAJ BHAVAN ROAD
INFANTRY ROAD
RACE COURSE ROAD
PALACE ROAD
DEVARAJ URS ROAD
QUEEN'S ROAD
CUNNINGHAM ROAD
BOWRING HOSPITAL RO
RAJ BHAVAN ROAD
INFANTRY ROA
PALACE ROAD PALACE ROAD
DEVARAJ URS ROAD
DOCTOR B R AMBEDKAR VEEDHI
QUEEN'S ROAD
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LINK ROAD
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SHESHADRI ROAD
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KEMPEGOWDA ROAD
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RAJARAM MOHAN ROY ROAD
LAVELLE ROAD
RESIDENCY ROAD
HAYES ROAD
DEVANGA HOSTEL ROAD
JC ROAD
7TH MAIN ROAD
RICHMOND ROAD
RICHMO
MISSION ROAD
SJP ROAD JC ROAD
SRI RAM MANDIR ROAD
MISSION ROAD