

MANUAL FOR PLANNING AND DEVELOPMENT OF URBAN ROADS AND STREETS



**INDIAN ROADS CONGRESS
2018**

MANUAL FOR PLANNING AND DEVELOPMENT OF URBAN ROADS AND STREETS

Published by:

INDIAN ROADS CONGRESS

Kama Koti Marg,
Sector-6, R.K. Puram,
New Delhi-110 022

NOVEMBER, 2018

Price : ₹ 700/-
(Plus Packing & Postage)

IRC:SP:118-2018

First Published : November, 2018

(All Rights Reserved. No part of this publication shall be reproduced, translated or transmitted in any form or by any means without the permission of the Indian Roads Congress)

Printed at India Offset Press, Delhi - 110 064
600 Copies

CONTENTS

S. No.	Description	Page No.
	Personnel of the Highways Specifications and Standards Committee	i-ii
	Abbreviations	iii
	Introduction	1
Chapter 1	Land Use and Transport Infrastructure	3
	1.1 Urban Roads and Streets Challenges	3
	1.2 Spatial Planning and Transport Policy	4
	1.3 Mobility Planning	5
Chapter 2	Urban Roads and Streets	7
	2.1 Design Principles, Objectives and Street Components	7
	2.2 Classification of Urban Roads and Streets	12
Chapter 3	Transport Network Planning	19
	3.1 Network Planning Principles	19
	3.2 Urban Road Network Pattern	19
	3.3 Existing Urban Road Network and Retrofitting	25
	3.4 Urban Road Network for Greenfield Development	28
	3.5 Principles of a Pedestrian Network	29
	3.6 Principles of a Non-Motorized Vehicle Network	30
	3.7 Principles of a Public Transport Network	31
	3.8 Multi-modal Integration	32
	3.9 Principles for Intersections, Interchanges and Traffic Rotaries	34
	3.10 Principles of Parking Management	35
	3.11 Principles of Street Vending Management	35
Chapter 4	Access Management	36
	4.1 Access Management Principles	36
	4.2 Service Roads	36
Chapter 5	Street Design and Implementation Process	38
	5.1 Vision Statement	38
	5.2 Institutional Framework	38
	5.3 Design Process for Existing Streets	39
	5.4 Proposed Concept Plan	50
	5.5 Tender Documents	54
	5.6 Implementation Plan	54
	5.7 Maintenance	54
	5.8 Performance Monitoring	54
Annexure 1:	Suggested Roles and Responsibilities of the Street Design Cell	55
Annexure 2:	Street Design Process for New Roads	56
Annexure 3:	Street Design Templates	57
References		75

LIST OF FIGURES

Fig. 1	Vicious Motorization Cycle	4
Fig. 2	Mode Priority in Street Design	5
Fig. 3	Complete Trip Chain	6
Fig. 4	Slow and Fast Zones of a Right of Way	9
Fig. 5	Different Zones of a Footpath; Source: IRC:103	10
Fig. 6	Benefits of Network Connectivity	20
Fig. 7	Measuring Block Length	21
Fig. 8	Maximum Block Length vs. Block Size: Plan A is Better Connected than Plan B	21
Fig. 9	Correlation between Intersection Density, Block Size and Block Length	22
Fig. 10	Road Network in Different Cities- New York, London, Chandigarh and Naya Raipur	22
Fig. 11	Comparative Network Connectivity Evaluation using Pedestrian Route Directness (PRD)	23
Fig. 12	Travel-Shed Analysis	24
Fig. 13	Impact/Benefits of Network Density on Road Widths, Signal Timings and Pedestrian Connectivity	25
Fig. 14	Street Network in Ahmedabad Central Business District; Source: Ahmedabad Urban Development Authority (AUDA)	26
Fig. 15	Grid Urban Road Network System	29
Fig. 16	Pedestrian and Cyclist Priority	31
Fig. 17	Existing and Redesigned Bus Shelters in Mumbai	32
Fig. 18	Safe Access to Mass Transit Stations	33
Fig. 19	Hierarchy of Parking Provision	35
Fig. 20	Location of Footpaths Relative to Service Lane	37
Fig. 21	Design and Implementation Process for Existing Streets	40
Fig. 22	Example of Topographic Survey	46
Fig. 23	Pedestrian Movement and Conflicts	47
Fig. 24	Activity Surveys	48
Fig. 25	Sample Line Drawing	51
Fig. 26	Proposed Concept Plan with all Street Elements	52
Fig. 27	Testing of a Proposed Intersection Design in Coimbatore	53

LIST OF TABLES

Table 1	Functions, Right-of-way, Planning Considerations, Design and Posted Speeds for Urban Roads and Streets in New Areas	15
Table 2	Functions, Right-of-way, Planning Considerations, Design and Posted Speeds for Existing Urban Roads and Streets	17
Table 3	Recommended Distance of Various Facilities from Entry/Exit of Mass Transit Station	33
Table 4	Types of Surveys	41
Table 5	Analyses and Proposals	49

**PERSONNEL OF THE HIGHWAYS SPECIFICATIONS
AND STANDARDS COMMITTEE
(As on 24.10.2017)**

1	Kumar, Manoj (Convenor)	Director General (Road Development) & Special Secretary to Govt. of India, Ministry of Road Transport and Highways, New Delhi
2	Singh, B.N. (Co-Convenor)	Addl. Director General, Ministry of Road Transport and Highways, New Delhi
3	Verma, Dr. S.K. (Member Secretary)	Chief Engineer (R) S,R & T, Ministry of Road Transport & Highways, New Delhi

Members

4	Bamezai, Prof. (Dr.) Gita	R&D, Indian Institute of Mass Communication, New Delhi
5	Basar, Toli	Chief Engineer, PWD, Arunachal Pradesh
6	Bhanot, Balraj	Chairman, TED, Bureau of Indian Standards, New Delhi
7	Bongirwar, P.L.	Secretary (Retd.), PWD Maharashtra
8	Gupta, D.P.	DG(RD) & AS (Retd.), Ministry of Road Transport and Highways, New Delhi
9	Jain, Prof. (Dr.) S.S.	Professor, Indian Institute of Technology, Roorkee
10	Jain, R.K.	Chief Engineer (Retd.), PWD Haryana
11	Kadiyali, Dr. L.R.	Chief Executive, L.R. Kadiyali & Associates, New Delhi <i>(Expired on 18.02.2016)</i>
12	Lal, Bhure	Chairman, Environment Pollution Control Authority, Delhi
13	Lal, Chaman	Engineer-in-Chief, Gurugram Metropolitan Development Authority, Haryana
14	Narain, Sunita	DG, Centre for Science and Environment, New Delhi
15	Nashikkar, J.T.	Secretary (Retd.), PWD Maharashtra
16	Pandey, R.K.	Member (Projects), National Highways Authority of India, New Delhi
17	Parida, Prof. (Dr.) M.	Dean, SRIC, Indian Institute of Technology, Roorkee
18	Pateriya, Dr. I.K.	Director (Tech), National Rural Roads Development Agency, New Delhi
19	Pawar, Ajit	Secretary (Retd.), PWD Maharashtra
20	Porwal, Dr. S.S. (VSM)	ADG (Retd.), Border Roads Organisation, New Delhi
21	Raju, Dr. G.V.S.	Engineer-in-Chief (Retd.), Roads & Building, Andhra Pradesh
22	Rawat, M.S.	Executive Director, AECOM India Pvt. Ltd.
23	Sarangi, D.	CGM, National Highways Authority of India, New Delhi
24	Sharma, M.P.	Chief Engineer, Ministry of Road Transport and Highways, New Delhi
25	Sharma, S.C.	DG(RD) & SS (Retd.), Ministry of Road Transport and Highways, New Delhi

26	Sheokand, Balbir Singh	Executive Engineer, PWD Haryana
27	Singh, Nirmaljit	DG(RD) & SS (Retd.), Ministry of Road Transport and Highways, New Delhi
28	Singh, Pawan Kumar	GM, 3M India Ltd.
29	Sinha, A.V.	DG(RD) & SS (Retd.), Ministry of Road Transport and Highways, New Delhi
30	Tawade, D.O.	Member (T), National Highways Authority of India, New Delhi
31	The Director, (Chandra, Dr. Satish)	Central Road Research Institute, New Delhi
32	The Director General, (Shrivastava, Lt. Gen. S.K.)	Border Roads Organisation, New Delhi
33	The Director General, (Mathur, Vishnu)	Society of Indian Automobile Manufacturers, New Delhi
34	The Engineer-in-Chief, (Sharma, Lt. Gen. Suresh)	Military Engineer Services, New Delhi
35	Tickoo, Bimal	Secretary (T), PWD Jammu
36	Tiwari, Prof. (Dr.) Geetam	Professor, Indian Institute of Technology, New Delhi
37	Varshney, Sharad	Superintending Engineer, Ministry of Road Transport and Highways, New Delhi
38	Verma, G.L.	MD, Engg and Planning Consultants Ltd., New Delhi

Corresponding Members

1	Baluja, Dr. Rohit	President, Institute of Road Traffic Education, New Delhi
2	Bhowmik, Sunil	Engineer-in-Chief (Retd.), Tripura
3	Kandasamy, C	DG(RD) & SS (Retd.), Ministry of Road Transport and Highways, New Delhi
4	The Director, (Patil, Capt. (Dr.) Rajendra B. Saner)	Central Institute of Road Transport, Pune

Ex-Officio Members

1	President, Indian Roads Congress	(Pradhan, N.K.), Engineer-in-Chief cum Secretary, Works Department, Odisha
2	Director General (Road Development) & Special Secretary to Govt. of India	(Kumar, Manoj), Ministry of Road Transport and Highways, New Delhi
3	Secretary General, Indian Roads Congress	Nirmal, Sanjay Kumar

ABBREVIATIONS

BRT	Bus Rapid Transit
CRRRI	Central Road Research Institute
IPT	Intermediate Public-Transit
IRC	Indian Roads Congress
ITS	Intelligent Transport System
MFZ	Multi-Functional Zone
MoHUA	Ministry of Housing and Urban Affairs
MoRTH	Ministry of Road Transport and Highways
MRT	Mass Rapid Transit
MUZ	Multi Utility Zone
NMT	Non-Motorized Transport
NMV	Non-Motorized Vehicles
PMV	Personal Motor Vehicle
PT	Public Transit
RoW	Right of Way
SUTP	Sustainable Urban Transport Project

MANUAL FOR PLANNING AND DEVELOPMENT OF URBAN ROADS AND STREETS

INTRODUCTION

India is facing rapid urbanization due to economic growth and industrialization. The urbanization process has been accompanied with increased urban sprawl, travel demand and trip distances. Therefore, it is imperative that urban mobility of people and goods be planned to minimize congestion and other social and environmental impacts. City planning shall be done with integrated land-use transport strategies to address people's needs and improve road mobility and safety for all users.

“Cities are for people.”

Sustainable mobility as a concept aims to reduce not only one's own travel footprint but also that of society. Therefore, a sustainable transport system should address not only an individual's mobility needs but also that of society at large. The Ministry of Housing and Urban Affairs (MoHUA) Government of India (GoI) has taken several steps in this direction, including the National Urban Transport Policy (NUTP) issued in 2006 and revisited in 2014. This policy aimed to bring about comprehensive improvements in urban transport services and infrastructure. The focus of policy is on moving people rather than vehicles. The MoHUA has also launched the National Mission on Sustainable Habitats, which addresses norms for parking and congestion charges, pedestrianization and cycling and proposes model regulations for integrating transport planning with master plans. The Smart City Mission – an initiative of the government - has also prioritized street design and improvement based on citizen consultations.

To respond to these initiatives, the Indian Roads Congress decided to prepare a Manual for Planning and Development of Urban Roads and Streets, which are principal infrastructure for movement of people and freight in a city. Accordingly, Urban Roads and Streets Committee (H-8) was entrusted with the task of preparing this Manual. The H-8 Committee in its meeting held on 20.05.2017 entrusted the work of preparation of initial draft to Shri Ashok Bhattacharjee. Later, Ms. Shreya Gadepalli was also requested to assist in the task of preparation of the draft. The initial draft prepared was discussed by the subgroup consisting of Shri D.P. Gupta, Ms. Paromita Roy, Prof. (Dr.) M. Parida, Dr. Ch. Ravi Sekhar, Dr. Sewa Ram and Ms. Sonal Shah and valuable inputs were received from Shri Amit Bhatt and Ms. Anjlee Agarwal. The H-8 Committee approved the document in its meeting held on 18.08.2017 for placing before the HSS Committee.

The composition of the H-8 Committee is given below:

Pawar, A.B.	Convenor
Parida, Prof. (Dr.) M.	Co-Convenor
Thakar, Vikas	Member-Secretary

Members

Agarwal, Anjlee	Roy, Paromita
Bagish, Dr. B.P.	Rustagi, S.K.
Gadepalli, Shreya	Sabnis, Sharad

Gupta, D.P.
Jaigopal, R.K.
Joshi, Dr. G.J.
Kamble, M.T.
Kide, P.M.
Narain, Sunita
Nath, Prem
Ram, Prof. (Dr.) Sewa
Ravi Sekhar, Dr. Ch.

Sanyal, D.
Sarkar, Prof. (Dr.) P.K.
Sharan, G.
Singh, Nirmaljit
Singh, Pawan Kumar
Srivastava, Sarvagya Kumar
Suriseti, Ramakrishna
Tiwari, Prof. (Dr.) Geetam

Corresponding Members

Kharwadkar, V.
Krishnan, Dr. Geeta

Prasad, R. Jai
Ramchandani, S.M.

Ex-Officio Members

President,
Indian Roads Congress

(Pradhan, N.K.), Engineer-in-Chief
cum Secretary, Works Department,
Odisha

Director General
(Road Development) & Special
Secretary to Govt. of India

(Kumar, Manoj), Ministry of Road
Transport & Highways

Secretary General,
Indian Roads Congress

Nirmal, Sanjay Kumar

The Highways Specifications & Standards Committee (HSS) considered and approved the draft document in its meeting held on 24th October, 2017. The Executive Committee in its meeting held on 2nd November, 2017 considered and approved the document for placing before the Council. The Council in its 213th meeting held at Bengaluru on 3rd November, 2017 considered and approved the draft for printing.

The manual advocates for an allocation of equitable road space for all users and creating pedestrian friendly, green streets to make our city spaces liveable, universally accessible and inclusive. This manual provides a framework for classifying, planning and developing road networks in new urban areas and retrofitting of existing urban roads and streets. It further outlines a street design and implementation process to enable the urban local bodies to effectively implement the planning guidelines.

CHAPTER 1

LAND USE AND TRANSPORT INFRASTRUCTURE

1.1 Urban Roads and Streets Challenges

The following challenges underpin the planning of transport infrastructure in urban areas in India.

1.1.1 *Land-use transport integration*

Urban planning has traditionally focused on land use planning with zoning regulations and development control norms for orderly development of the city. Urban roads and streets constitute the basic transport infrastructure in towns and cities. The urban road and street network system is largely determined by land use planning through either the Master Plan or the Development Plan of the city.

An integrated land use- road network system provides safe and comfortable transport system. Currently, the secondary and local street network is either not developed or not planned in consonance with the primary network system of the master plan/development plan. This leads to skewed distribution of traffic over the street network, concentration of local traffic at a few major junctions on arterial roads leading to long queue lengths, while the secondary network remains under-utilized. This also forces pedestrian/non-motorized transport to take long detours even for short distances, and even inducing them to switch to motorized modes, which exacerbates motorized traffic congestion.

1.1.2 *Zoning regulations and development controls*

Specific zoning regulations, development control norms and building bylaws guide the development of buildings, but there are no defined norms in the Master Plan/Development Plans to guide road network planning and development process. For example, there are no street bylaws for regulated development of roads in urban areas.

1.1.3 *Auto dependence and large trip distances*

Excessive Right of Way (ROW) for arterial roads with scant respect for needs of vulnerable road users leads to automobile oriented development, especially in new cities and urban extension areas. Compact cities ensure that work trips are kept to a minimal distance. There is need for improved facilities for pedestrians and cyclists.

1.1.4 *Urban road infrastructure development*

The current practice of single land-use planning leads to sprawl in cities that results in increased motorization requiring more road capacity (**Fig. 1**). There is need to ensure that the geometric design norms and standards for urban roads are suitable for all users, not only motorized traffic. Safe mobility and universal accessibility need to be an integral part of planned urban transport development.

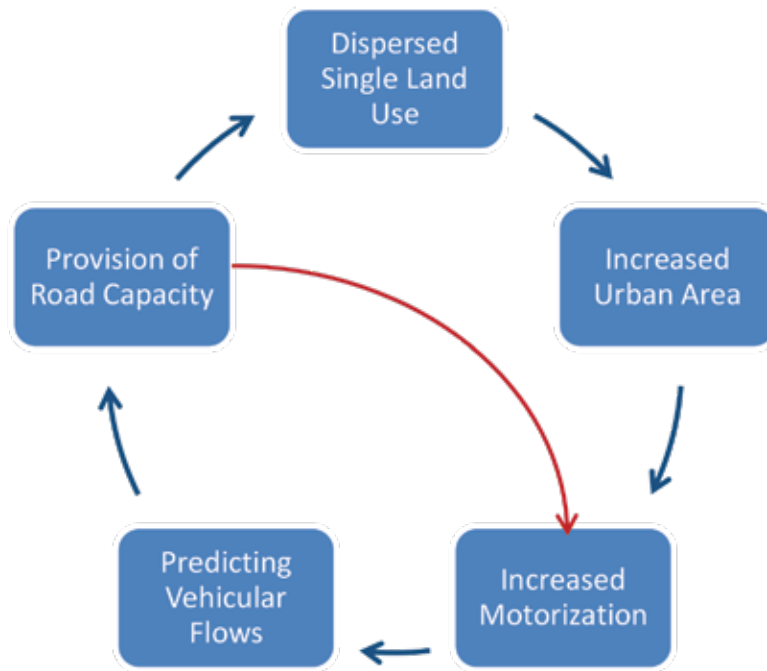


Fig. 1 Vicious Motorization Cycle

1.1.5 *Impact on congestion, air quality and road safety*

High speeds are one of the primary causes of road fatalities. Urban roads facilitating high vehicle speeds create unsafe environments for pedestrians/cyclists in particular, due to lack of facilities for these road users. The high level of motorization also results in high level of pollution with negative health impact.

In the present scenario, with enhanced socio-economic base, affordability of population has increased and the number of private motorized vehicles has increased significantly in recent decades. As a nation, there is no cap on owning private vehicles. Vehicle ownership continues to increase unchecked, supported with growing aspirations of a rapidly urbanizing society. However, it is necessary to strengthen and improve the public transport system so that people are attracted to shift their mode of travel from car to walk/cycle or use of non-motorized transport for short trips and to public transport for long trips. Simultaneously, travel demand management measures such as on-street parking management, congestion pricing, road tolls and transit-oriented development are required to disincentivize the use of personal motor vehicles.

1.2 Spatial Planning and Transport Policy

Integrated spatial and transport planning in existing and new urban areas can reduce motorized travel by influencing the location, scale, density, design and mix of land uses, making it safer and easier for people to access jobs, shopping, leisure facilities and services by public transport, walking and cycling. Compact, dense and interconnected layouts are more suitable for providing public transportation. Urban growth should be encouraged along mass rapid transit corridors to achieve transit oriented development i.e. compact growth supported with mixed land uses, dense street networks and mixed income housing. Consistent application of these planning policies will

reduce reliance on private modes of transport and enable people to make sustainable transport choices. This will help in reducing congestion and air pollution.

1.3 Mobility Planning

Mobility planning in urban areas should give priority to the needs of pedestrians, cyclists and non-motorized transport along with motorized vehicles. Focus should be given to mode priority indicated in **Fig. 2**.

An urban mobility system should be inclusive and equitable in terms of system adoption and infrastructure provisions. Planning should be done at two tiers: city-level and zonal, ward or local area plan levels, such that macro city level plans are duly supported with a second tier of detailed plans to facilitate walking and cycling within and across neighbourhoods, thereby providing sustainable, short distance, safe travel options.

1.3.1 Mode priorities

The priority in urban transport planning should shift from planning for motor vehicles to non-polluting, energy efficient, people-centric and safe modes of transport providing access to all.

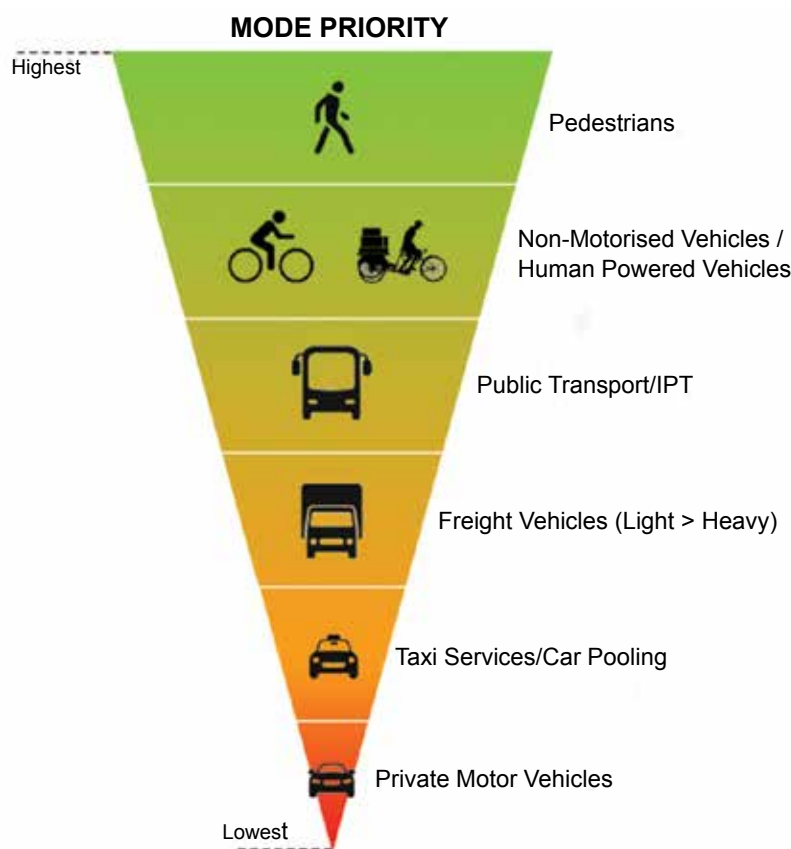


Fig. 2 Mode Priority in Street Design

1.3.2 Universal accessibility

Improved mobility is a crucial and necessary element in alleviating poverty for all, including women, children, elderly and persons with disabilities. It provides opportunities for everyone

to play an active role in society - economically, socially and culturally. Universally accessible design will help increase the number of people walking and the number of people using public transportation. To ensure this, pedestrian environment and all transit systems – buses, bus shelters, Bus Rapid Transit (BRT), metro, rail terminals and stations etc. should not only be accessible, but should also provide continuity in the complete trip chain.

A complete trip chain (connectivity and seamless journey) starts from the point of origin to the walk/commute, cycle and/or wait for transport, boarding, travel and alighting followed by the walk/commute to the final destination (**Fig. 3**). Each trip chain must ensure pedestrian safety for all including persons with and without disabilities. Any break in the trip chain results in lack of access and independent mobility. Inaccessible links require taking an indirect route, increasing travel times, fatigue, uncertainty and potential modal conflicts. The goal must be for people to have access to all vehicles and the full-service area, as well as the pedestrian environment.¹

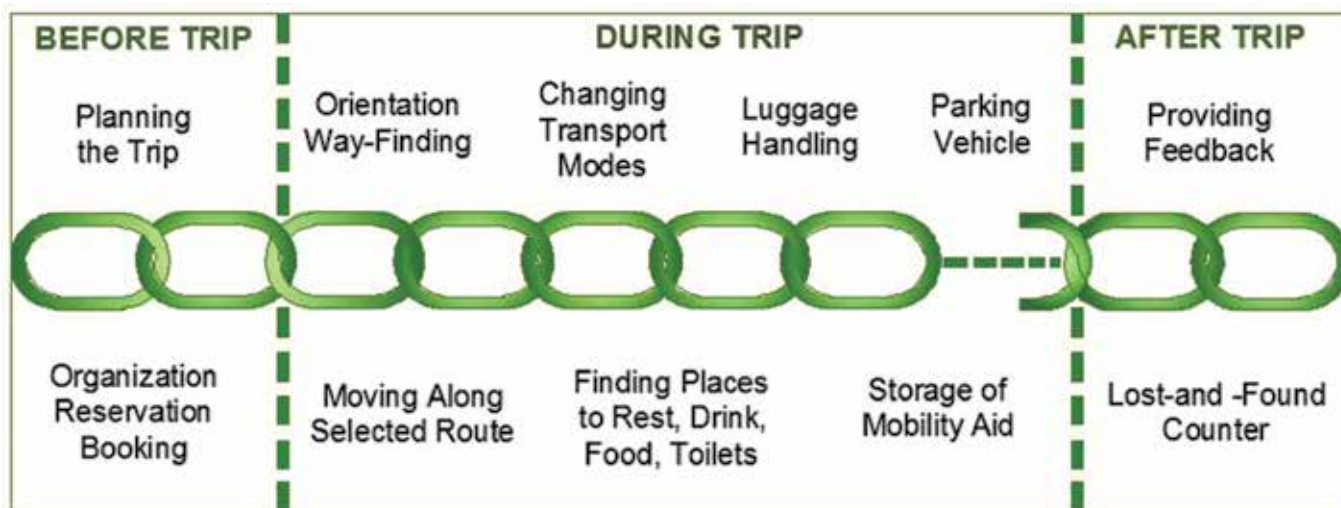


Fig. 3 Complete Trip Chain

1.3.3 Urban road safety

Road safety and safety audits are becoming imperative in the current scenario where number of road accidents and fatalities have been escalating every year. Inclusion of safety audits at the planning and design stage of road projects should become a practice to cater to the needs of vulnerable road users especially pedestrians, wheelchairs, cyclists, non-motorized transport (NMT) users and two-wheelers. The Urban and Regional Development Plan Formulation and Implementation Guidelines (URDPFI) provide safety indicators to be followed and inclusion of road safety in development plans, mobility plans etc. For road safety audits, IRC:SP:88 - 2019 "Manual on Road Safety Audit" should be referred.

¹World Report On Disability, World Health Organization, (WHO), 2011

CHAPTER 2 URBAN ROADS AND STREETS

Good street planning and design is a key element of smart development. Streets are places where land use and transportation connect. The planning and design of road networks must prioritize accessibility to destinations by different groups of people – men, women, children, elderly and persons with disabilities - using different modes of transport i.e. walking, cycles, cycle rickshaws, buses, mini-buses, auto-rickshaws, e-rickshaws, two-wheelers and four wheelers. .

The major components of street network planning are:

- **Pattern of the street network:** A pattern of streets with fine grid of narrow streets that result in numerous connections and short blocks, makes it easier to move around - people have more than one way to reach a destination. Street design that considers this concept can help reduce traffic congestion. It can also make it possible for children to walk or bicycle to school.
- **Right of way:** Streets with balanced distribution of right of way for non-motorized users and motorized vehicles improve movement and safety of all users in mixed traffic conditions.
- **Physical elements along the streetscape:** Streets are designed for all users as per existing and projected demand, including various components such as carriageway, footpath, trees , road side furniture required to make ‘complete streets’.

2.1 Design Principles, Objectives and Street Components

Urban Roads refer to the primary network comprising of arterial roads of a city-region and provide intra-city and regional connectivity through rapid transit, high frequency public transit and motor vehicle movement. They connect large land uses such as terminals, city-regional health, education, recreation and transit facilities, and constitute an ‘Arterial Road’ network. These roads have provision of footpaths for pedestrians and may require physical segregation for non-motorized vehicles.

Urban Streets refer to the secondary network of the city comprising of ‘Sub-Arterial, Collector and Local Streets’. These connect neighbourhoods to the arterial road network and provide accessibility within neighbourhoods. While collector roads also connect large land uses, this network is pedestrian and non-motorized vehicle focused with an emphasis on creating active public spaces.

2.1.1 *Design principles*

- **Accessibility:** People should be able to move safely and seamlessly through the city.
- **Safety and Comfort:** Streets are safe, clean and walkable.
- **Ecology:** Streets are climate resilient and reduce impact on the natural environment.
- **Social Concerns:** Streets cater to the access needs of local communities, elderly and persons with disabilities.

2.1.2 *Design objectives*

The design objectives of urban roads and streets shall be:

- Allocate the right of way equitably between motorized and non-motorized road users duly catering to the needs of pedestrians, cyclists and public transport users, thereby promoting both accessibility and mobility. Encourage people to walk, cycle and use public transport by making the experience safer, comfortable and pleasant.
- Create safe, traffic calmed environments that promote healthy lifestyles and respond to the distinctive nature of communities and places.
- Provide climatic resilience and promote environmental sustainability by incorporating, enhancing natural features (trees, natural drains, foliage) and preventing/mitigating negative socio-economic and environmental impacts.
- Create lively and vibrant public spaces catering to the needs of all, especially the most vulnerable road users such as women, children, the elderly and persons with disabilities.

2.1.3 *Street components and definitions*

TERMINOLOGY

Accessibility: Facilities offered to people to reach social and economic opportunities, measured in terms of time, cost, comfort, and safety that are associated with reaching such opportunities.

Bus Rapid Transit (BRT): High quality bus based mass transit system that delivers fast, comfortable, reliable and cost-effective urban mobility through the provision of segregated right-of-way infrastructure, rapid and frequent operations, and excellence in marketing and customer service.

Complete Streets: Streets that are designed for all uses as per existing and projected local demand, including all modes of mobility as well as street vending, trees, street furniture etc.

Greenway: A waterway or strip of land set aside for recreational use of environmental protection and where vegetation is encouraged along with exclusive facilities for cycling and walking.

Mass Rapid Transit (MRT): A high quality public transport system characterized by high capacity, comfort, overall attractiveness, use of technology in passenger information system, and ensuring reliability using dedicated right of way for transit vehicles (i.e. rail tracks or bus lanes).

Non-Motorized Transport (NMT): Human powered transportation such as walking and cycling.

On-Street Parking: The space occupied by vehicles to park along the edge of the street or carriageway which otherwise could have been used by motorized or non-motorized traffic.

Intermediate Public Transport: The term refers to informal public transport, including vehicles like auto rickshaw, vans, tempo, jeeps, private city buses and private city minibuses that operate on a shared or per seat basis on informally organized routes operated by private sector and has

intermediate stops. The service may or may not have a predefined “fare structure.” The term “Intermediate Public Transport (IPT)” means the same.

Public Transport (PT): Shared passenger vehicle which is publicly available for multiple users. The term “PT” as used in this document and other toolkits includes city buses and Mass Rapid Transit (MRT).

Parking Management: A mechanism to ensure the efficient use of street space, and over time, parking fees can be introduced to manage demand.

Sustainable Transport Modes: Walking, cycling, and public transport (including a regular bus service as well as an MRT system) are categorized as “sustainable modes” of urban transport because when compared with personal motor vehicles, they consume least amount of road space and fuel per person-km and also cost much less to build the infrastructure.

Traffic calming: Traffic calming measures ensure pedestrian and vehicle safety by reducing speed. Traffic calming slows down vehicles through vertical displacements, horizontal displacement, real or perceived narrowing of carriageway, material/colour changes that signal conflict point.

- **Right of Way (RoW):** It is the space between two property lines, reserved in any legal development plan/planning document/spatial plan for the movement of all transport modes. The RoW of roads is designated under the ‘Transportation’ land use (Fig. 4).
- **Cross section of the road:** It shows the space allocation for all motorized vehicles (cars, scooter, buses etc.), non-motorized vehicles (cycle, cycle rickshaws etc.), pedestrians, medians, street furniture, utilities, etc. within the right of way.

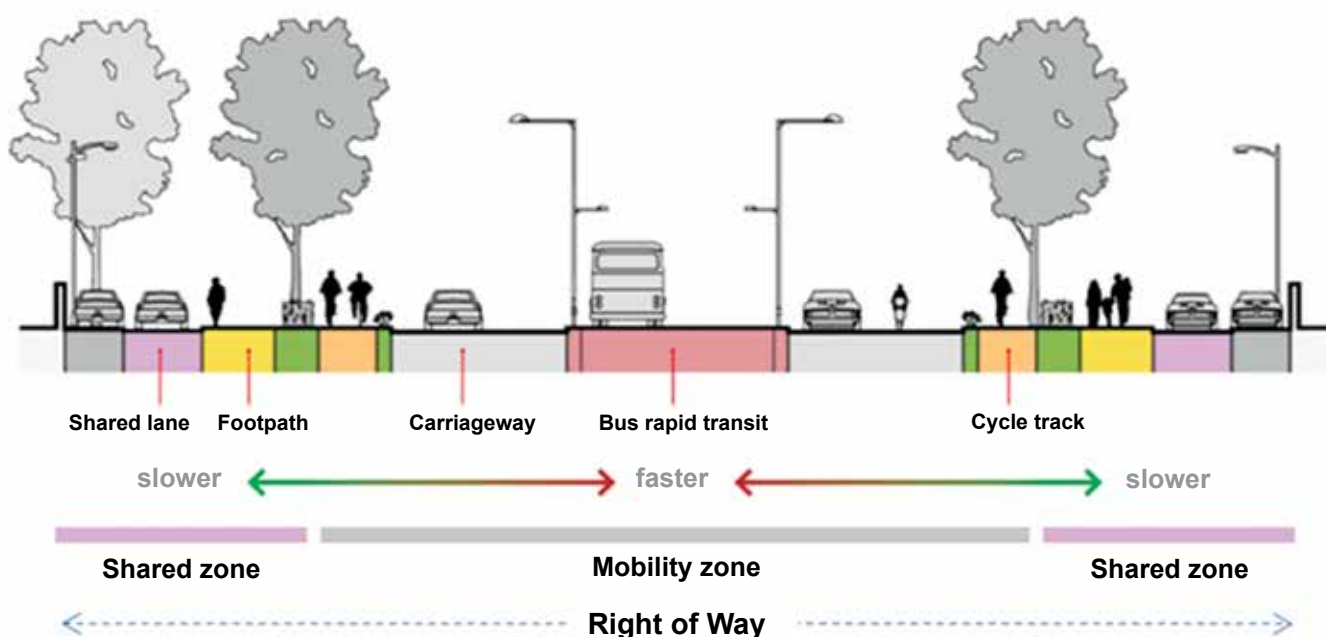


Fig. 4 Slow and Fast Zones of a Right of Way

Surface Space

- **Footpath:** It is a space reserved for movement of pedestrians and consists of a dead/frontage zone, a pedestrian zone and a multi-functional zone for supporting amenities for pedestrians and other road users. (Fig. 5)

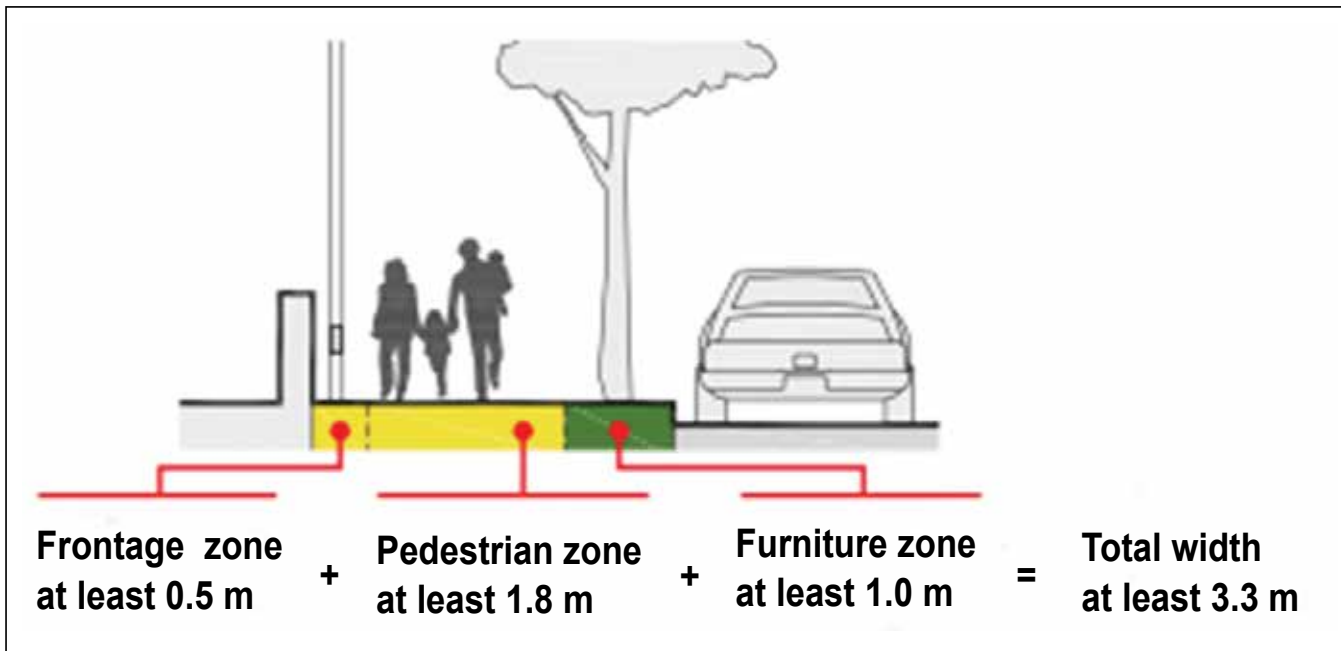


Fig. 5 Different Zones of a Footpath; Source: IRC:103

- **Non-Motorized Vehicle Track:** It is a space reserved for movement of only non-motorized vehicles like cycle, cycle rickshaws and hand pull carts.
- **Multi-functional Zone:** A multi-functional zone ranges one to two metres wide. It is provided between the pedestrian zone and carriageway to provide amenities. It accommodates tree pits, storm water swales, auto-rickshaw stands, cycle-rickshaw stands, hawker zones, paid car parking, bus stops, traffic police booths, telecom boxes, fire hydrants, junction boxes, street lights/pedestrian lights etc.
- **Bus Shelters and Intermediate Public Transport (IPT) Stands:** This includes bus shelters and IPT shelters to provide a sheltered waiting area for users.
- **Traffic Calming Measures:** Traffic calming slows down vehicles through vertical displacement, horizontal displacement, real or perceived narrowing of carriageway, material/colour changes that signal conflict point, or complete closure of a street. These improve both pedestrian and vehicle user safety.
- **Pedestrian Crossings:** These can be indicated through road markings or as table top crossings and facilitate crossing at mid-blocks and intersections.
- **Trees/Landscaping:** Trees provide shade for the entire right of way. Planting can serve as water percolation pits, while improving the aesthetics of the street.

- **Street Lighting:** This encompasses lighting for the carriageway, footpaths and Non- Motorized Vehicle (NMV) tracks.
- **Street Vending:** Vendors provide affordable goods and services for all road users, especially pedestrians and cyclists. They are considered as a street element for Indian streets.
- **Signage:** This includes mandatory, and regulatory, cautionary, direction and information traffic signages for pedestrians, cyclists, public transport and motor vehicle users.
- **Carriageway:** It is a space meant for movement of motorized vehicles and can be divided/undivided depending upon the category of road. Fair share of space within right of way should be provided for pedestrians, cyclists and other non-motorized vehicles while planning for the carriageway. On local streets where the carriageway maybe shared by pedestrians, non-motorized and motorized vehicles, speeds shall be reduced through traffic calming elements.
- **Service Lanes:** These are traffic calmed, shared streets provided at the edge of arterial roads to provide property access, where there are too many entrances (say at every 15 m or less).They can increase the mobility function of the main carriageway while also maintaining liveability for non-motorized road users.
- **Parking Access:** The space occupied by vehicles to park along the edge of the street or carriageway which otherwise could have been used by motorized or non-motorized traffic.

Underground Space

- **Urban Street Utilities:** All city underground sewers, water, electric and other communication cable lines should be properly mapped and re-laid wherever possible /feasible in underground service ducts or Hume pipes. Careful location and planning of physical infrastructure services and urban utilities is critical –to allow easy access for regular repair and maintenance of utilities, while causing minimum disruption or disturbance to other street users.

The conventional construction of open/covered roadside drain systems has drained out precious rain water without capturing the potential of recharging depleting ground water. In many instances, the covering of natural drains, dumping of waste and sewage has also resulted in impeding the natural cleaning of drains. Therefore, there is an urgent need to focus on storm water drainage system planning and management.

- **Common Utility Ducts/Duct Bank:** Common ducts may be provided for city level utilities (such as sewers, water supply, electricity etc.) and separately for street utilities (such as local storm water drains, information technology, telecom, street lighting cables, etc.) during the laying/relaying/retrofitting of roads, in order to facilitate efficient repairs, maintenance of all systems, without disruptions of the street during such activities. For more details, refer to IRC:98.

2.2 Classification of Urban Roads and Streets

The following typologies of urban roads with specific functions and development norms be adopted:

- Urban Expressways
- Arterial Road
- Sub Arterial Road
- Collector Street
- Local Street
- Non-Motorized Transport (NMT) Streets and Greenways

2.2.1 *Urban Expressways*

- An urban expressway is defined as an urban arterial highway for high speed regional passenger and goods traffic from inter-city highways/expressways to connect to other inter-city highways entering the city at specific locations. These are full access control and having divided carriageways provided generally with grade separators at intersections. In new areas, urban expressways maybe planned as a primary ring road around a city or metropolitan region to connect with the regional road network comprising primarily of National Highways, State Highways etc.
- All regional level passenger and freight terminal centres maybe located on this ring road to have faster access, regional distribution and intermodal transfer opportunity.
- Urban expressways should connect to the arterial road network at specific locations.
- Entry junctions with highways and primary ring roads of the city may have flyovers with/without cloverleaf structure to facilitate signal free movement of traffic either to destined or bypassing the city.
- Bypass roads may be considered for inter-city traffic, instead of new urban expressways running through city boundaries. Town planning schemes may be considered to obtain land for bypass roads to avoid the displacement of people and social and financial costs associated with land acquisition. Bypass roads shall be considered after a careful evaluation of alternate route options and a comparison of social, environmental/pollution and economic costs to users and non-users.

2.2.2 *Arterial Roads*

A general term denoting a road/street primarily for through traffic, usually on a continuous route. Arterial roads facilitate mobility across the city and connect to long distance destinations within/outside the city, while providing safe NMT facilities. Safety for pedestrians will be ensured by providing dedicated footpaths, at-grade pedestrian crossing with a median refuge and at distances as per IRC:103. A dedicated non-motorized vehicle track network shall be provided. On-street parking shall be prohibited or restricted, except when there is space available for a service lane with parking.

- Arterial roads in new areas shall have a right of way of 45-60 m with future provision for mass rapid transit.
- In existing areas with a right of way less than 45 m, the arterial roads shall be classified based on their function in the street network and ensure minimum pedestrian and/or cycling facilities. The redesign shall increase passenger capacity by increasing frequency of mainline buses and/or implementing high-quality mass rapid transit, such as Bus Rapid Transit (BRT) or metro-rail.

2.2.3 *Sub-Arterial Roads*

A general term denoting a road/street primarily for through traffic usually on a continuous route but offering somewhat lower level of traffic mobility than the arterial road. These are larger collector streets meant for movement through neighbourhoods and to connect to arterial roads. Sub-arterial roads shall have adequately sized footpaths as per IRC:103, continuous non-motorized vehicle network and street furniture to cater to the adjacent land use. The medians shall include pedestrian refuges for safe street-level crossing and at distances as per IRC:103.

- In new areas, the right of way shall vary from 30-45 m along with future provision for mass transit.
- In existing areas with a right of way less than 30 m, the sub-arterial roads can be classified based on their function in the street network and after ensuring minimum pedestrian, public transport and/or cycling facilities. The redesign shall be based on increasing passenger capacity by increasing frequency of mainline buses and/or implementing high-frequency and high-quality mass rapid transit, such as Bus Rapid Transit (BRT) or metro-rail.

2.2.4 *Collector Streets*

- A street for collecting and distributing traffic from and to local streets and also for providing access to arterial/sub-arterial roads. They shall be designed with dedicated footpaths and crossings as per IRC:103. Various speed reduction measures will be employed to limit vehicle speeds to less than 40 kmph and ensure safety of NMT users. Public transport feeder buses may operate on such streets. In new areas, the right of way shall vary from 15-30 m.
 - Collector roads with a right of way of 24 m and above may have a divided carriageway with 2 lanes per direction, pedestrian facilities as per IRC:103 and cycle tracks. The median shall be intermittent to allow for connectivity to local streets and U-turns.
 - Collector roads with a right of way less than 24 m may have an undivided carriageway with one lane per direction and pedestrian facilities as per IRC:103. A combined cycle track maybe considered for roads with right of way varying between 20-24 m.

2.2.5 *Local Streets*

- A street for access to residence, business or other abutting property. Its primary function shall be for local traffic and access to properties and not through movement of traffic. For new areas, the right of way is recommended at 10-15 m.
- In existing areas, local streets may have a right of way less than 10 m, which primarily provide access to properties. In such cases, the streets may not have a dedicated footpath and can be designed as shared space that gives priority to non-motorized transport users. Various traffic calming elements will be employed to ensure that vehicle speeds are below 20 kmph - safe for intermingling of pedestrians, cyclists, and motor vehicles. Staggered on-street parking, chicanes, speed humps can serve as traffic calming measures.

2.2.6 *Non-Motorized Transport Streets and Greenways*

Non-motorized transport only streets: All motor vehicle traffic will be prohibited, using barriers and enforcement to prevent their entry and encroachment of non-motorized transport space. Such streets will be designed in compliance with universal access guidelines, with bicycle parking, and access for emergency response vehicles. Commercial deliveries to properties on such streets will be restricted to outside of normal hours. Streets shall be identified where pedestrian density is the highest, such as those in important market streets, historical and cultural areas, and develop them as non-motorized transport only streets with plazas, seating, trees and structures for shade, as well as space for organized street vending.

Non-motorized transport: Public transport only streets: Private motorized vehicle traffic will be prohibited but public transport services will be allowed, in addition to pedestrians and cyclists. Streets shall be identified based on the amount of non-motorized transport traffic and the need for access by and through movement of public transport modes.

Greenways: The spaces along natural features such as water bodies, lakes and parks shall be developed as a network of exclusive facilities for walking and cycling only, with a variety of public spaces and natural features. Motor vehicle traffic will be prohibited on these roads. Such greenways shall have a minimum clear width of 7.5 m to accommodate two-way movement of cyclists and pedestrians.

The planning considerations for new roads (**Table 1**) and redesign of existing roads (**Table 2**) are given for the above classes of roads. The right of way for various hierarchies of existing roads needs to allocate space drawing a balance between the needs of motorized vehicles and non-motorized vehicles including pedestrians.

Table 1 Functions, Right-of-Way, Planning Considerations, Design and Posted Speeds for Urban Roads and Streets in New Areas

Sl. No	Activity	Urban Expressways and Bypass Roads (1)	Arterial Roads (2)	Sub Arterial Roads (3)	Collector Streets (4)	Local Streets (5)	Non-Motorized Transport Pathways and Greenways (6)
1	Function	<ul style="list-style-type: none"> Caters to long distance regional passenger and goods traffic either bypassing the city or destined to selected parts of the city. 	<ul style="list-style-type: none"> Primary network of a city. Provide intra-city long distance travel by multi-modal transportation system connecting all major city land uses. Facilitate intercity/regional trips by connecting with the highway and expressway network. 	<ul style="list-style-type: none"> Secondary network of the city connecting multiple neighbourhoods to the arterial roads. 	<ul style="list-style-type: none"> Supplements the secondary street network system by improving accessibility within and across neighbourhoods. 	<ul style="list-style-type: none"> Network providing non-motorized travel opportunity within the neighbourhood and access to motorized traffic as last mile connectivity. 	<ul style="list-style-type: none"> Streets catering only to pedestrians and non-motorized transport (including cycles and cycle rickshaws, cycle carts).
2	Right of Way (ROW)	45-60 m	45-60 m	30-45 m	15-30 m	10-15 m	<ul style="list-style-type: none"> 4m for pedestrian path. 7.5m for pedestrian and two-way non-motorized vehicle path.
3	Planning Considerations for New Streets Streets shall be designed as described in Section 2.1.1 and 2.1.2	<ul style="list-style-type: none"> Uninterrupted vehicular movement with traffic interchanges with highway and arterial roads. Access to properties shall be facilitated through service roads. Alignment for Bypasses should be decided by the City/Municipal/Development Authorities, in consultation with the road agency. Interchanges may be provided at highway-highway junctions. 	<ul style="list-style-type: none"> Network of 1000m x 1000m. The right of way shall allocate space for future provision of a mass rapid transit system. Dedicated space for footpaths and non-motorized vehicle tracks to create a safe network for pedestrians and cyclists. Pedestrian crossings at intersections and mid-blocks as per IRC:103. Carriageway with maximum 3 lanes per direction. On-street parking is not permitted. 	<ul style="list-style-type: none"> Network of 500m x 500m. The right of way shall allocate space for future provision of a mass rapid transit system. Dedicated space for footpaths and non-motorized vehicle tracks to create a safe network for pedestrians and cyclists. Pedestrian crossings at intersections and mid-blocks as per IRC:103. 	<ul style="list-style-type: none"> Network of 250m x 250m. 24-30m right of way: Divided carriageway with a maximum of 2 lanes per direction, pedestrian facilities as per IRC:103 and cycle tracks. Median shall be intermittent to allow for connectivity to local streets and U-turns. <24m right of way: Undivided carriageway with one lane per direction and pedestrian facilities as per IRC:103. Combined cycle track maybe considered for roads with RoW varying between 20-24m. On-street parallel motor vehicle parking after providing pedestrian and non-motorized vehicle facilities. 	<ul style="list-style-type: none"> Network of 125m x 125m. Dedicated footpaths as per IRC:103 Streets with right of way less than 12m may be considered in consultation with the road department. These can be traffic calmed shared space with priority to non-motorized transport. Lane width of 3m. 	<ul style="list-style-type: none"> Spacing should be <125m. No restrictions on pedestrian and non-motorized vehicle access from adjoining properties. Compound walls shall not be higher than 1m Motorized vehicles and their parking are not permitted. Designated parking for non-motorized vehicles to be provided.

Sl. No	Activity	Urban Expressways and Bypass Roads (1)	Arterial Roads (2)	Sub Arterial Roads (3)	Collector Streets (4)	Local Streets (5)	Non-Motorized Transport Pathways and Greenways (6)
3			<ul style="list-style-type: none"> Access to properties may be facilitated by service roads. Interchanges are only permitted with expressways in peri-urban areas. 		<ul style="list-style-type: none"> Parking to be accommodated in the multi-functional zone. No flyover/elevated roads and interchanges on this class 		
4	Design Speeds (km/h)						
	Plain	80	60	60	40	30	Not applicable
	Rolling	70	50	50	40	30	Not applicable
	Mountainous	60	40	40	30	20	Not applicable
	Steep	60	40	40	30	20	Not applicable
5	Posted Speeds (kmph)						

The posted speed is subject to adjoining land-use conditions. Posted speeds shall be 20kmph on road stretches within 100m of land uses with significant pedestrian cross movement. These are educational institutions, hospitals, retail stretches, areas around mass transit stations. Traffic calming measures need to be adopted in such situations.

Table 2 Functions, Right-of-Way, Planning Considerations, Design and Posted Speeds for Existing Urban Roads and Streets

Sl. No	Activity	Urban Expressways and Bypass Roads (1)	Arterial Roads (2)	Sub Arterial Roads (3)	Collector Streets (4)	Local Streets (5)	Non-Motorized Transport Pathways and Greenways (6)
1	<p>Planning Considerations for Existing Streets</p> <ul style="list-style-type: none"> Existing streets shall be designed as described in Section 2.1.1 and 2.1.2 	<ul style="list-style-type: none"> Expressways passing through the city/urban area shall be designed for uninterrupted vehicular movement with traffic interchanges with highway and arterial roads. 	<ul style="list-style-type: none"> The RoW of numerous arterial roads in Indian cities is less than 45m. The classification shall be based on its function and not on the right of way. Dedicated space for footpaths and non-motorized vehicle tracks to create a safe network for pedestrians and cyclists. Pedestrian crossings at intersections and mid-blocks as per IRC:103. Divided carriageway with maximum 3 lanes per direction. On-street parking is not permitted. The road capacity shall be augmented by public transport i.e. increasing passenger capacity by providing mass rapid transit and/or upgrading public transport systems, and non-motorized transport. Before flyovers and elevated corridor proposals are taken up, an alternative analysis of capacity augmentation by public transport, pedestrian and non-motorized transport improvements shall be conducted. Additionally, a quantitative comparison of the environmental, economic and social benefits and cost of both proposals shall be conducted. 	<ul style="list-style-type: none"> Dedicated space for footpaths and non-motorized vehicle tracks to create a safe network for pedestrians and cyclists. Pedestrian crossings at intersections and mid-blocks as per IRC:103. Divided carriageway with maximum 2 lanes per direction. Parking management shall be introduced. Parallel motorized vehicle parking after providing pedestrian and non-motorized vehicle facilities. Parking to be accommodated in the multi-functional zone. Interchanges are prohibited. The road capacity shall be augmented by public transport i.e. increasing passenger capacity by providing and/or upgrading public transport systems and promoting non-motorized transport. Before flyovers, and elevated corridor projects are taken up, an alternatives analysis of capacity augmentation by public transport, pedestrian and non-motorized transport improvements shall be conducted. 	<ul style="list-style-type: none"> Collector streets with 24m and above right of way: Divided carriageway with a maximum of 2 lanes per direction, pedestrian facilities as per IRC:103 and cycle tracks. The median shall be intermittent to allow for connectivity to local streets and U-turns. Collector streets with right of way less than 24m may have an undivided carriageway with maximum one lane per direction and pedestrian facilities as per IRC:103. Combined cycle track maybe considered for collector streets varying between 20-24m. Motorized on-street parking maybe permitted. On-street parking management to be introduced. Parallel motorized vehicle parking providing pedestrian and NMV facilities. 	<ul style="list-style-type: none"> Streets with right of way greater than 12m shall provide dedicated footpaths and pedestrian crossings as per IRC:103. Streets with right of way less than 12m may be traffic calmed shared space with priority to non-motorized transport modes. Lane width of 3m. Some local streets in the neighbourhood should be developed as car free streets i.e. only for walking/ cycling for enhanced community life. 	<ul style="list-style-type: none"> Can be created by combining side or rear open spaces of buildings. No restrictions on pedestrian and NMV access from adjoining properties. Compound walls shall not be higher than 1m. Motorized vehicles and their parking are not permitted. Designated parking for non-motorized vehicles to be provided.

Sl. No	Activity	Urban Expressways and Bypass Roads (1)	Arterial Roads (2)	Sub Arterial Roads (3)	Collector Streets (4)	Local Streets (5)	Non-Motorized Transport Pathways and Greenways (6)
2	Design Speeds (km/h)		<ul style="list-style-type: none"> Construction of any flyover/elevated roads on arterial roads after above considerations should be accommodated within the carriageway without encroaching/affecting any space already developed or reserved for non-motorized vehicles/pedestrians and other street elements. Pedestrian foot over bridges and subways may be discouraged. Service roads shall be considered for local pedestrian and other traffic. 	<ul style="list-style-type: none"> A quantitative comparison of the environmental, economic and social benefits and cost of both proposals shall be conducted. Construction of any flyover/elevated roads after above considerations should be accommodated within the carriageway without encroaching on or affecting any space already developed or reserved for non-motorized vehicles/pedestrians and other street elements. 	<ul style="list-style-type: none"> Parking to be accommodated in the multi-functional zone. No flyover/elevated roads and interchanges on this class. 		
		80	60	60	40	30	Not applicable
		70	50	50	40	30	Not applicable
		60	40	40	30	20	Not applicable
		60	40	40	30	20	Not applicable
3	Posted Speeds (km/h)		The posted speed is subject to adjoining land-use conditions. Posted speeds shall be 20kmph on road stretches within 100m of land uses with significant pedestrian cross movement. These are educational institutions, hospitals, retail stretches, areas around mass transit stations. Traffic calming measures need to be adopted in such situations.				

CHAPTER 3 TRANSPORT NETWORK PLANNING

3.1 Network Planning Principles

Urban road network systems are influenced by land use systems and development patterns, with a hierarchy of settlements based on urban functions, activities, and land constraints etc. However, the ease and quality of access to land uses and their functional inter-relationships are determined by connectivity. In the absence of network planning guidelines, often city and neighbourhood level accessibility is overlooked in the urban planning process leading to congested major roads and poorly connected neighbourhoods.

The urban roads and street network shall:

- Provide an efficient and safe access for 'people' and facilitate movement of non-motorized traffic and pedestrians along with motorized traffic.
- Accommodate the travel demand of all road users with provision of space for all modes satisfying the safety, equity and environmental criteria.
- Achieve universal accessibility with the specific provisions for people with disability/restricted mobility/elderly, women and children for their safety and convenience.
- Develop a complete road network system to distribute traffic over the entire network rather than concentration of traffic along a few corridors. The arterial road network shall be supplemented with secondary network of sub-arterial, collector and local streets through detailed planning at the ward, local area plan levels.
- Develop a secondary network for short distance (localised) non-motorized and motorized travel and integrate it with the arterial network for long distance travel.
 - Provide direct pedestrian and non-motorized connectivity to transit stops and facilities in the neighbourhood.
 - Provide bus corridor space with adequate infrastructure support for efficient transit options to enhance modal share in favor of public transport.
 - Provide designated and demarcated spaces for all public transport modes with strategically located spaces for Intermediate Public Transport (IPT-hired/shared modes) stands for efficient last mile connectivity option for people. Provide traffic control measures (signals, signages and road markings) on all urban arterial and collector roads for regulated movement of traffic.
- Suburban road network planning with low density, gated communities serviced by high speed corridors and cul-de sacs shall be avoided. These increase walking and cycling distances and do not facilitate planning for public transit.

3.2 Urban Road Network Pattern

Urban road network density, which determines block sizes are a key indicator of auto-centric or walkable neighbourhoods and cities. In several cities today, in the absence of well-developed secondary and local street networks, the local traffic tends to accumulate at a few major

junctions, causing large queue lengths and congestion at these locations, while majority of the internal streets remain under-utilized due to discontinuity. Lack of these networks also forces pedestrians and NMT to take long detours even for short distances, thus inducing them to switch to motorized modes, which in turn further adds to motorized traffic congestion. Often solutions such as flyovers and grade separators are proposed and implemented to reduce delays at major junctions while a better and sustainable solution may lie in increasing road network connectivity in the area and provide more route-options.

Network connectivity improves mobility, transportation choices, road safety and creates economic vibrancy (Fig. 6).

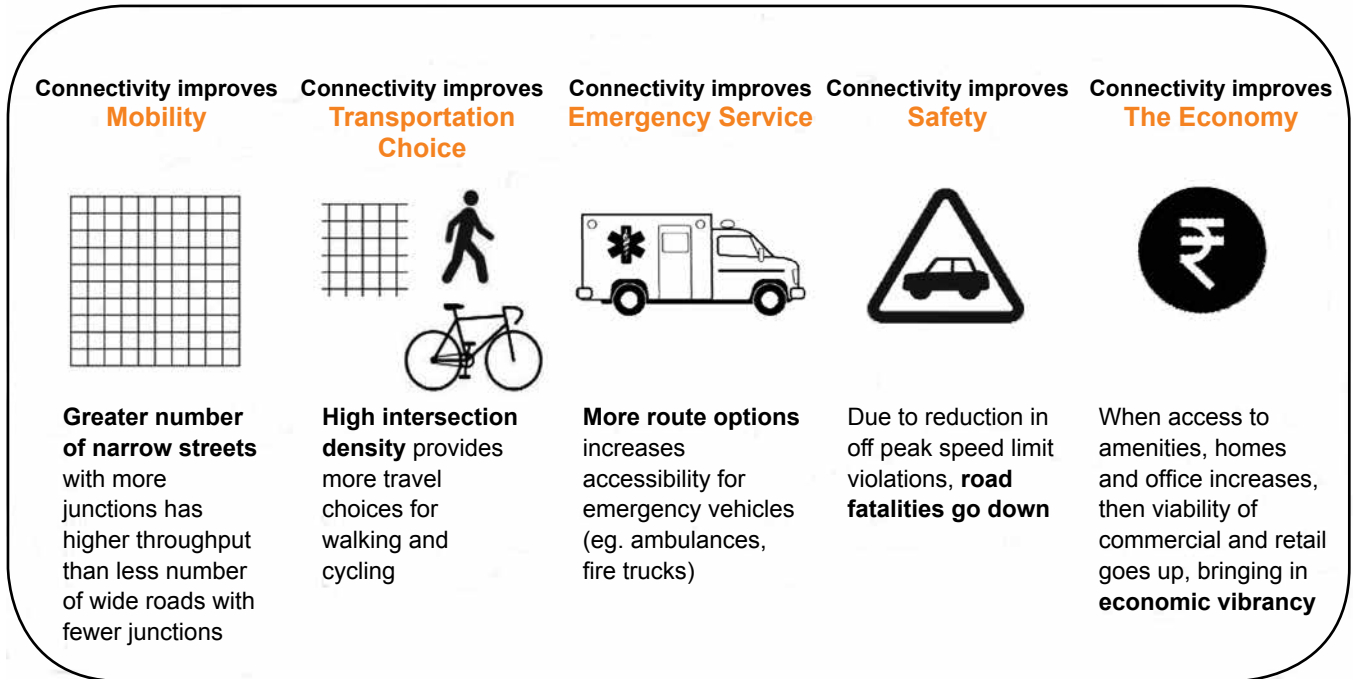


Fig. 6 Benefits of Network Connectivity

3.2.1 Tools for measuring network connectivity

Connectivity is the primary purpose of any transportation network as it links locations between which people want to travel. Travel is a "derived demand" i.e. we travel to access locations, and the mode of travel is determined amongst other factors, by the road network. Travel demand modelling assigns a cost to travel that includes a time "cost". All else being equal, shorter travel times are preferred. This is particularly true for bicycling and walking, which are slower than motorized travel. There are practical limits to how far a person will walk or cycle and therefore increased network connectivity can reduce travel distances for all modes, including walking and bicycling.

An additional benefit of increased connectivity for these modes is having a wider range of routes from which to choose. A cyclist, for example, might choose a slightly longer route if he/she can use a bicycle lane, a street with less traffic, or a less steep hill. However, pedestrians invariably prefer shorter distances for travel.

Measuring the network connectivity is a critical tool in evaluating existing neighbourhoods for traffic throughput, efficient dispersal and walkability. It also provides a public policy tool to establish performance standards for new and/or existing developments.

Network connectivity can be measured in any of the following ways:

3.2.1.1. Block Length Standard

A block is typically defined as the smallest fully enclosed polygon bounded by features such as publicly accessible motorized/mixed-traffic roads or streams, on all sides (**Fig.7**). Shorter blocks mean more intersections and, therefore, shorter travel distances and a greater number of routes between locations. For measuring overall connectivity of an existing area, the average block length for a defined area should not be more than say 125 m. Any block length that exceeds 125 m on any side must provide additional pedestrian thoroughfares. A more direct method is the perimeter of an urban block. A walkable block perimeter ranges from 400 m to 500 m.

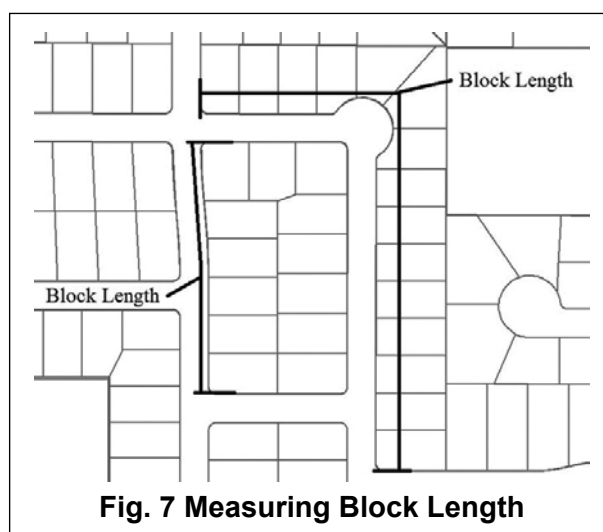


Fig. 7 Measuring Block Length

3.2.1.2. Block Area Standard

The block area should not be greater than 15000 m². However, this is generally inadequate in measuring pedestrian connectivity because in case length to width ratio of the block is high, it may still mean long detours for the pedestrians (**Fig. 8**).

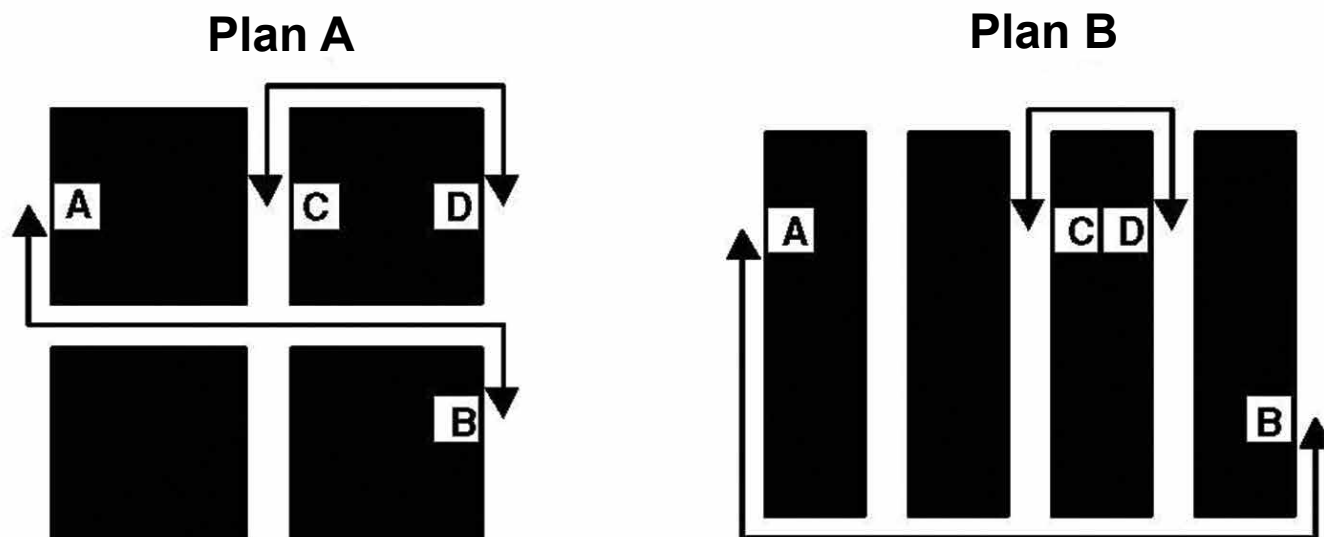
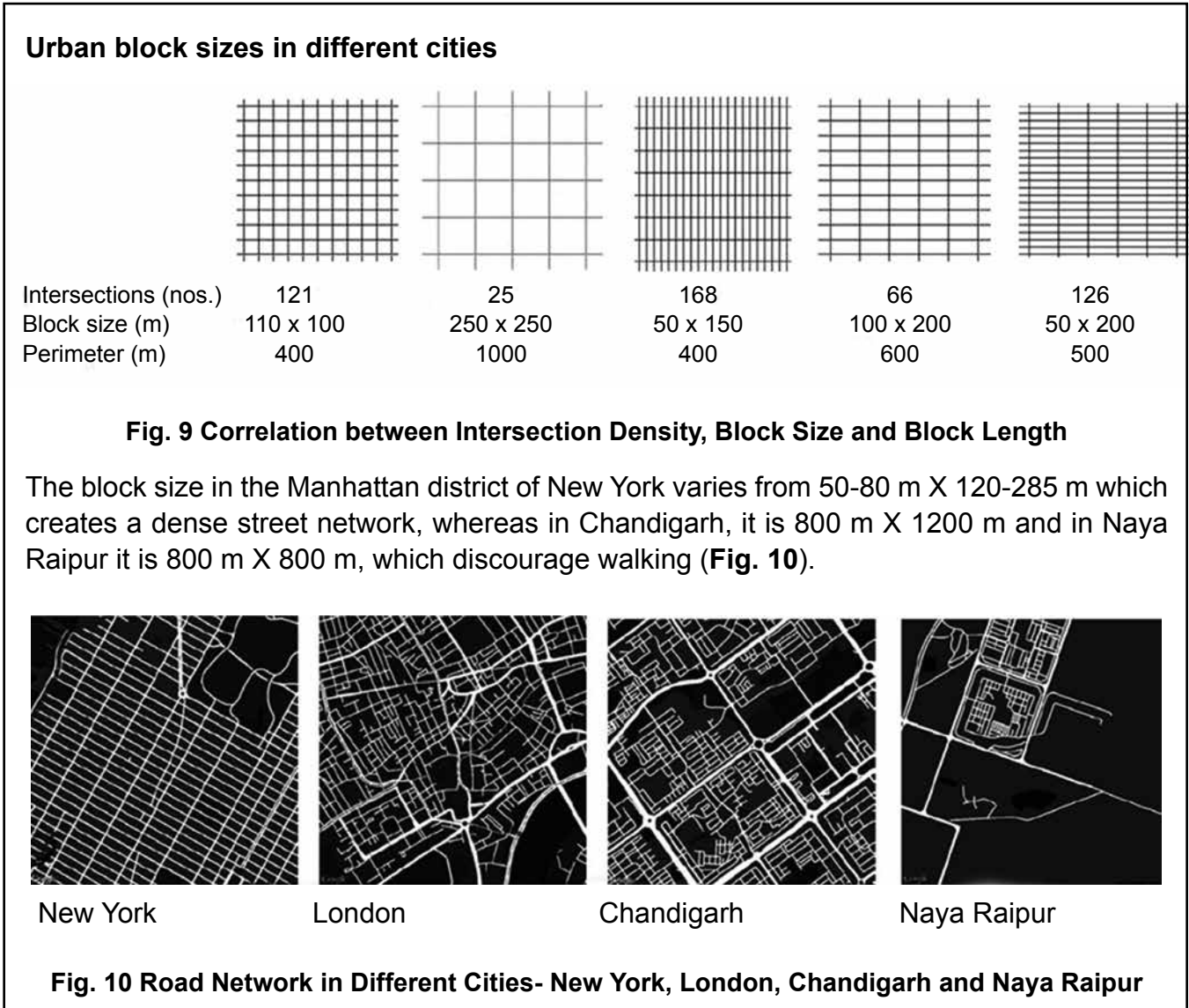


Fig. 8 Maximum Block Length vs. Block Size: Plan A is Better Connected than Plan B

3.2.1.3. *Urban Block Sizes, Intersection Density and Spacing*

Urban block sizes are a direct reflection of intersection density and spacing (see **Fig. 9** for broad relationship). A well-connected street network would require around 100 junctions per m², excluding cul-de-sacs and dead-ends. Intersection spacing is a common form of measurement for network connectivity as it is easy to measure. As mentioned above, a well-connected street network would have a vehicular road at least every 250 m and a pedestrian or non-motorized transport pathway at least every 125 m. In case of hilly areas, these desirable distances may be reduced to 100 m and 80 m respectively. **Fig. 10** illustrates case example of a few cities.



3.2.1.4. *Pedestrian Route Directness (PRD)*

Pedestrian Route Directness (PRD) is the ratio of route distance to straight-line distance for two selected points (**Fig. 11**). The lowest possible value is 1.00, where the route is the same distance as the "crow flies" distance. Numbers closer to 1.00 indicate a more direct route, representing a more connected network. Neighbourhoods with well-connected grid street networks and

relatively short blocks would have PRDs of 1.1-1.5, which is preferable. Neighbourhoods with more curvilinear streets and cul-de-sacs may have PRDs more than 1.5 (1.6-2.5). These are to be avoided.



Fig. 11 Comparative Network Connectivity Evaluation using Pedestrian Route Directness (PRD)

3.2.1.5. *Travel-shed Analysis*

The actual distance travelled for a trip is a primary factor in determining whether a person walks or drives. This measure directly reflects that factor. The level of network connectivity and amenity access within an area can be assessed by measuring the share of property entries within actual (shortest) walking distance of any destination (using GIS – Geographic Information System software). The closer the travel-shed comes to filling the circle, the better connected it is (**Fig. 12**). The availability of amenities such as primary schools, parks and transit stops within 400 m walking distance of homes is a desirable standard for a well-planned, connected neighbourhood.

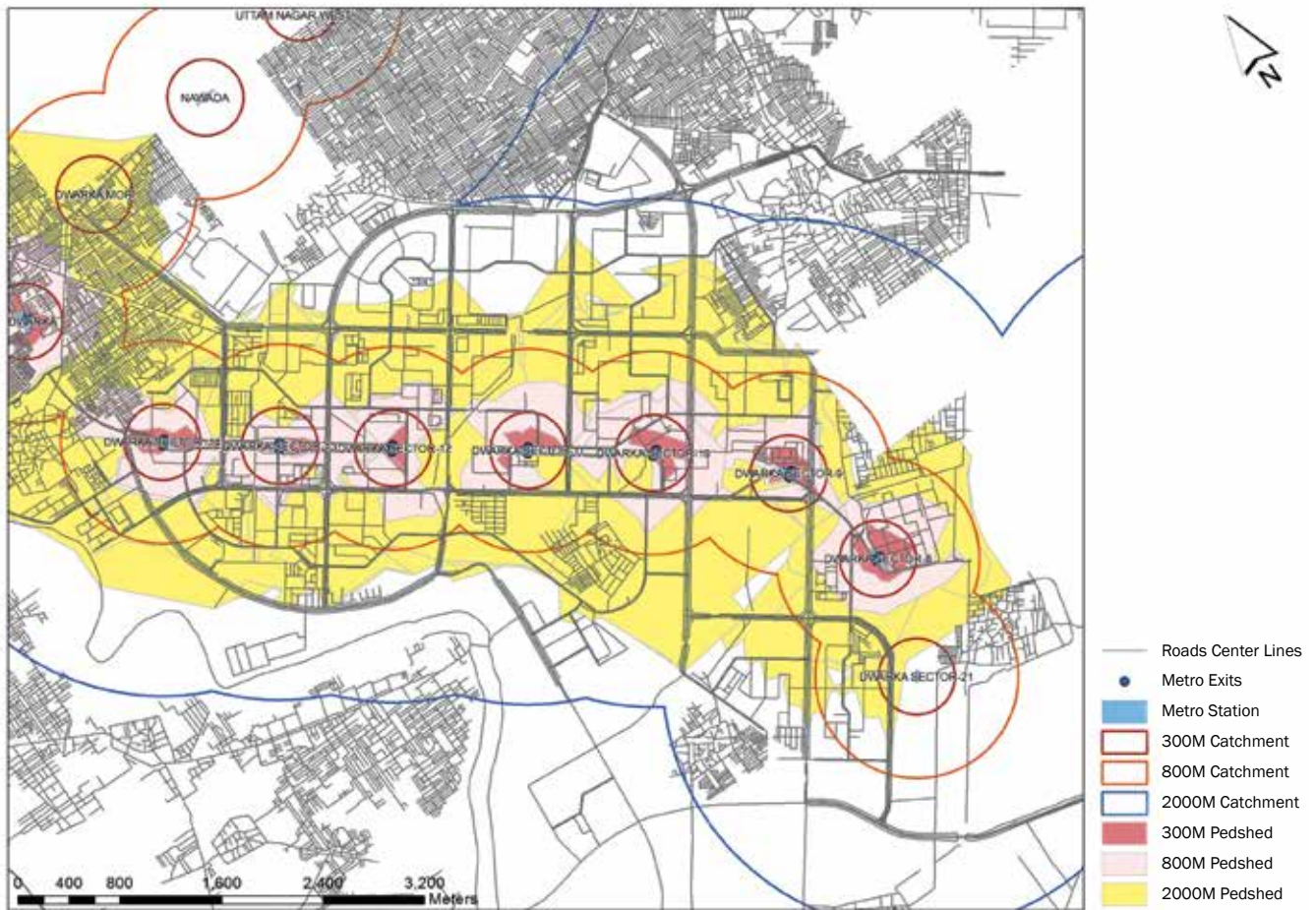


Fig. 12 Travel-shed Analysis

3.2.2 Road network and throughput correlation

Increasing network connectivity is the most efficient way to reduce walking and cycling trip distances as well as congestion on major arterials. Distributing traffic over a network of streets and junctions reduces maximum queue length at any junction, reduces signal cycles and delays, and therefore increases overall traffic throughput through the entire area (**Fig. 13**). Further, due to optimal/reduced road width requirements of a dense network, lower speeds can be maintained during off-peak hours, thus enhancing road safety. A dense road network can have the following impact on travel² :

- Reduce vehicle kilometres travelled by 30%-40%.
- Reduce motorized trip lengths by about 10%-20%.
- Reduce walking distances by about 35%-45%.

²UTTIPEC and DIMTS Technical Report (2012), Optimization of Transport Networks in Proposed Transit Oriented Development Zones.

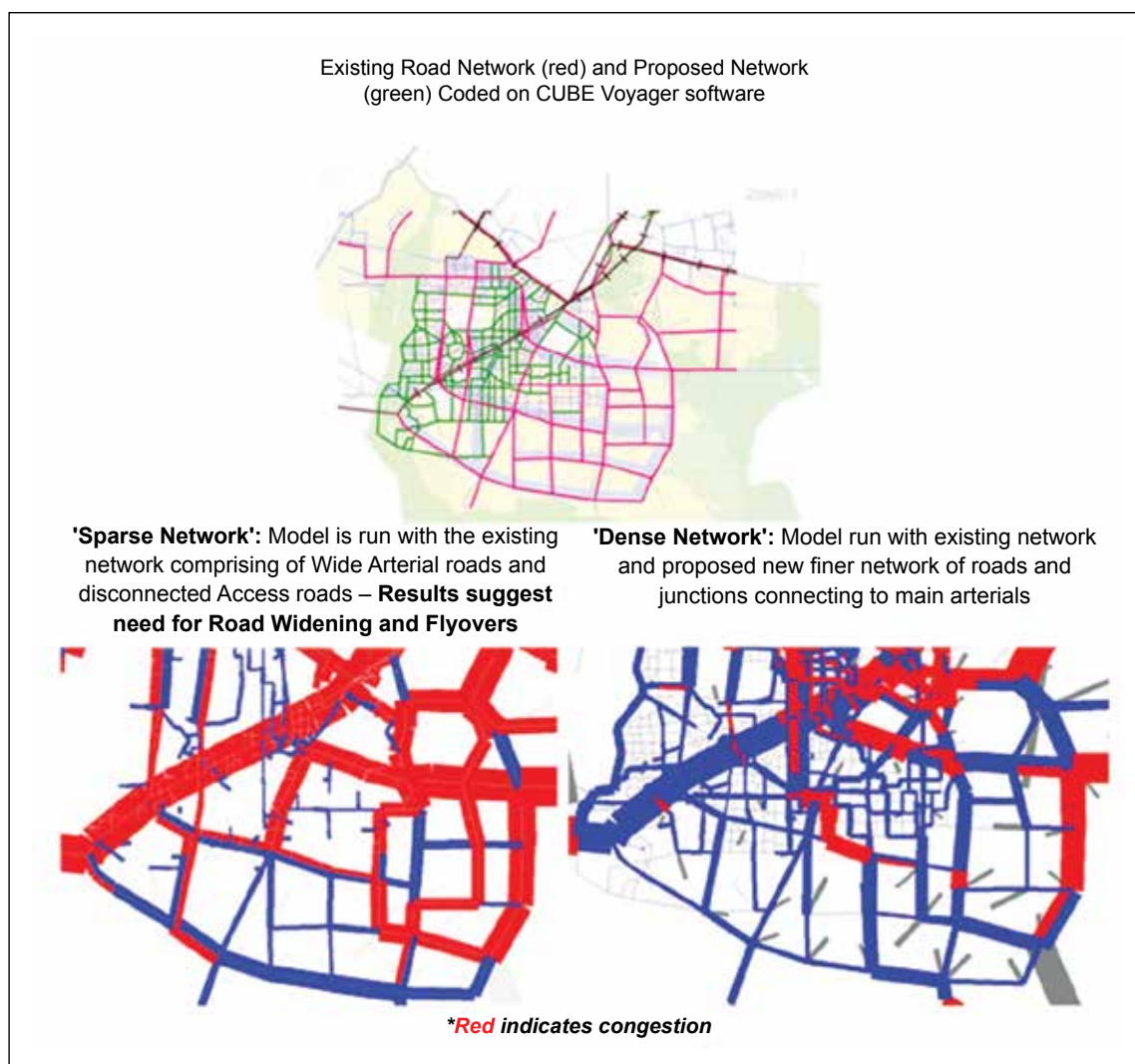


Fig. 13 Impact/Benefits of Network Density on Road Widths, Signal Timings and Pedestrian Connectivity

3.3 Existing Urban Road Network and Retrofitting

The present road network currently favours motor vehicles and has a negative impact on the quality of public life, as they occupy majority of the public spaces for movement and parking. As much as 70-80% percent of the road space is occupied by 20-30 percent of people using private motor vehicles. The retrofitting of existing roads shall accommodate space for all users - pedestrians, non-motorized vehicles, public transport modes/buses, and motor vehicles and functions and activities. The following strategies may be adopted:

- Network of Complete Streets:** Urban roads shall be redesigned as “Complete Streets” to rebalance the existing allocation of road space by providing safe, comfortable and convenient environment for pedestrians, cyclists and public transport users and to enable universal accessibility. Additionally, wherever possible capacity of the existing road network shall be augmented by pedestrian and non-motorized paths at <125 m c/c (through public open spaces and plazas, along natural drains, side setbacks of buildings) to reduce block sizes and walking distances. This is critical in case of small

and medium sized cities where non-motorized transport may constitute 40-50 percent of all trips³.

In Gujarat, amendment to the State Town Planning Act has enabled cities like Ahmedabad (Fig. 14) to prepare second tier of Local Area Plans (LAP) and create denser street networks to increase traffic carrying capacity and reduce walking distances. The current average block perimeter in the central business district in Ahmedabad is 743 m. The proposed LAP creates an improved street network with average block perimeter of 416 m. The new streets were created by:

- Addition of new development plan roads
- Addition of existing private roads
- New roads through margins and open spaces
- Roads through plots and requiring demolition

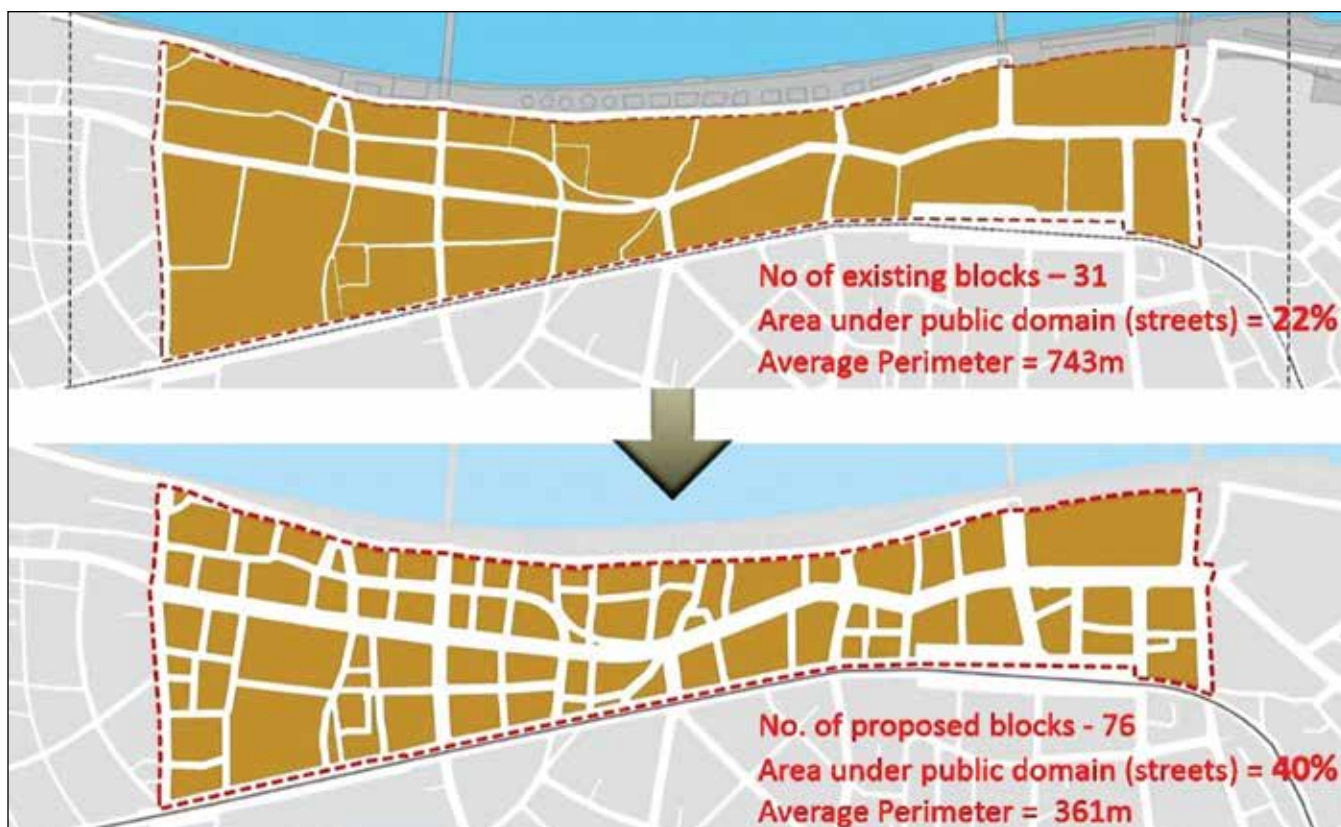


Fig. 14 Street Network in Ahmedabad Central Business District;
Source: Ahmedabad Urban Development Authority (AUDA)

- **Function to Precede Planned Character:** Due to inadequate development of a secondary street network in many Indian cities, particularly small and medium sized cities, and adjoining land-use conditions, often streets function differently from their planned character. For example, even arterial streets may have frequent property access in the city core or serve primary and secondary schools. Thus, it is essential to balance their throughput roles with consistent abutting land use while prioritizing safety of vulnerable road users.

³MoUD 2008

- **Distribution of Motorized Traffic:** Existing road network shall be re-designed and managed to distribute high traffic volume over multiple roads with smaller right of way, instead of stand-alone corridor/junction capacity improvement strategies. Area level traffic management plans - comprising of pedestrianization, parking management, augmenting public transport services and traffic rerouting - shall be prepared for dense city cores with narrow streets or areas with significant mixed traffic. Projects to improve the network connectivity such as railway over bridges and pedestrian/non-motorized transport pathways shall be considered.
- **Parking Management:** Area level parking management shall be taken up as part of network improvement for effective utilization of the capacity of roads. On street parking spaces shall be organised, designated, and demarcated after leaving clear and uniform carriageway space and footpaths as per norms for orderly and smooth movement of vehicles, cyclists and pedestrians respectively.
- **Increase Passenger Capacity by Improving Public Transit Capacity:** Urban road capacity can be increased by focusing on an efficient and sustainable mode of increasing passenger carrying capacity. This shall be done by investing in and increasing public transport capacity (especially in small and medium sized cities) and where relevant, Bus Rapid Transit (BRT), Metro, Light Rail Transit (LRT), etc.
- **One-way Streets and Couplets:** The goals for one-way streets should be carefully reviewed, and maybe created to accommodate rapid transit (such as BRT) corridors or pedestrian zones and in mixed-use districts with heavy footfall. One-way streets can also be created to improve capacity of motorized vehicles. However it may result in longer trip distances, higher vehicle speeds and may also make it difficult for new drivers to navigate who are not familiar with the locality. In such cases, signalized pedestrian and cyclist crossings and traffic sign ages shall be considered to enable safe crossing and inform drivers. One-way streets should not have in a carriageway of more than 3 lanes.

Further, couplets with two-phase signalling can be created when a parallel street at a close distance of 150-200 m is available. Where one-way streets or couplets are provided, two-way movement for non-motorized transport modes must be ensured. However, violations such as contra flow movement may be expected. To address the same, strict enforcement measures may be necessary. Service lanes are often useful in reducing such violations.

- **Redesign of Streets in Urban Core Areas:** The streets in dense urban cores in India often have inconsistent and narrow streets with a predominance of walking, cycling, use of intermediate public transport and two-wheelers. The use of 4-wheeler personal motor vehicles is marginal. The mobility challenge in these cities is to provide a safe, comfortable and convenient experience. Therefore, these streets require special attention as per the following guidelines:
 - An area-based traffic management approach should be adopted, consisting of a network of one-way streets, signalized intersections, non-motorized transport priority streets and restricted through movement of personal motorized four-wheelers. Due to the dense network of streets, vehicular traffic can be dispersed without endangering pedestrians.

- Arterial roads should have preferably no more than two carriageway lanes per direction. Pedestrian facilities should be provided as per IRC:103 with pedestrian crossings at all intersections and along mid-blocks not exceeding 50 m. Parallel motorized vehicle parking can be designated after providing pedestrian facilities. On-street parking management should be introduced on major thoroughfares.
- On streets less than 12 m right of way, pedestrians and vehicles may share the carriageway. Motor vehicle speeds shall be reduced with traffic calming elements or a protected space for pedestrians may be considered as motorized two-wheelers create an uncomfortable environment for pedestrians. This can be created with bollards or with a dedicated footpath, where space is available. The spacing of bollards should not be less than 1000 mm at key access points to permit movement of wheelchairs.
- Enforcement of the above measures shall be ensured.

3.4 Urban Road Network for Greenfield Development

The urban planning approach needs a paradigm shift to a grid street network with dense, mixed use development to reduce travel lengths and auto dependency in cities. The close grid network will help uniform distribution of motorized traffic over the network and avoid congestion at critical points on arterial roads and neighbourhood roads simultaneously. This will also increase mobility space for all non-motorized modes. Whereas long distance travel can be catered by high speed, high capacity transit and motorized traffic on arterial network, the short/medium distance travel can largely be catered by a combination of para-transit and non-motorized modes on the secondary street network system. (**Fig. 15**) About 25-30 per cent of land space should generally be reserved in the Master Plan/Development Plan for all categories of roads.

Urban road networks in Greenfield development areas may adopt the following strategies:

- **Master Plan/Development Plan:** The Master Plan giving layout of the arterial and sub-arterial network, regional-city level pedestrian, non-motorized transport routes and greenways for the city. The comprehensive transport/mobility plan maybe developed within the overall vision of the Master Plan/Development Plan.
- **Zonal/Ward Level Plans:** The collector and local street network maybe detailed out at the zonal and ward levels, ensuring that they are connected across neighbourhoods and to the city-wide network. The Town Planning Scheme is a land pooling and readjustment scheme, which has enabled creation of a secondary network of streets in states like Maharashtra and Gujarat. It is an alternative to land acquisition and minimises displacement of people. It can be considered as a tool for road network development in new areas.
- **Vehicular Grid of 250 m:** A vehicular grid of 250 m x 250 m of collector roads should form an efficient network system for residential and non-residential areas. A grid of 1000 m x 1000 m comprising of arterial roads shall be superimposed on the network system to provide motorized public and private transport movement connecting all major commercial, office and terminal complexes. A closer grid of 125 m x 125 m of local and non-motorized transport street network would further enhance cycle and

pedestrian movement with some streets free from motor vehicles. The location of bus nodes should be provided only on collector streets and above with an influence zone of 500 m.

- **Integration across City, Zone and Neighborhood:** The integration of city, zone and neighborhood levels is important for an efficient urban transport system. In the neighborhood level greater emphasis is given on pedestrian/non-motorized vehicle users as well as accessibility of public transport.

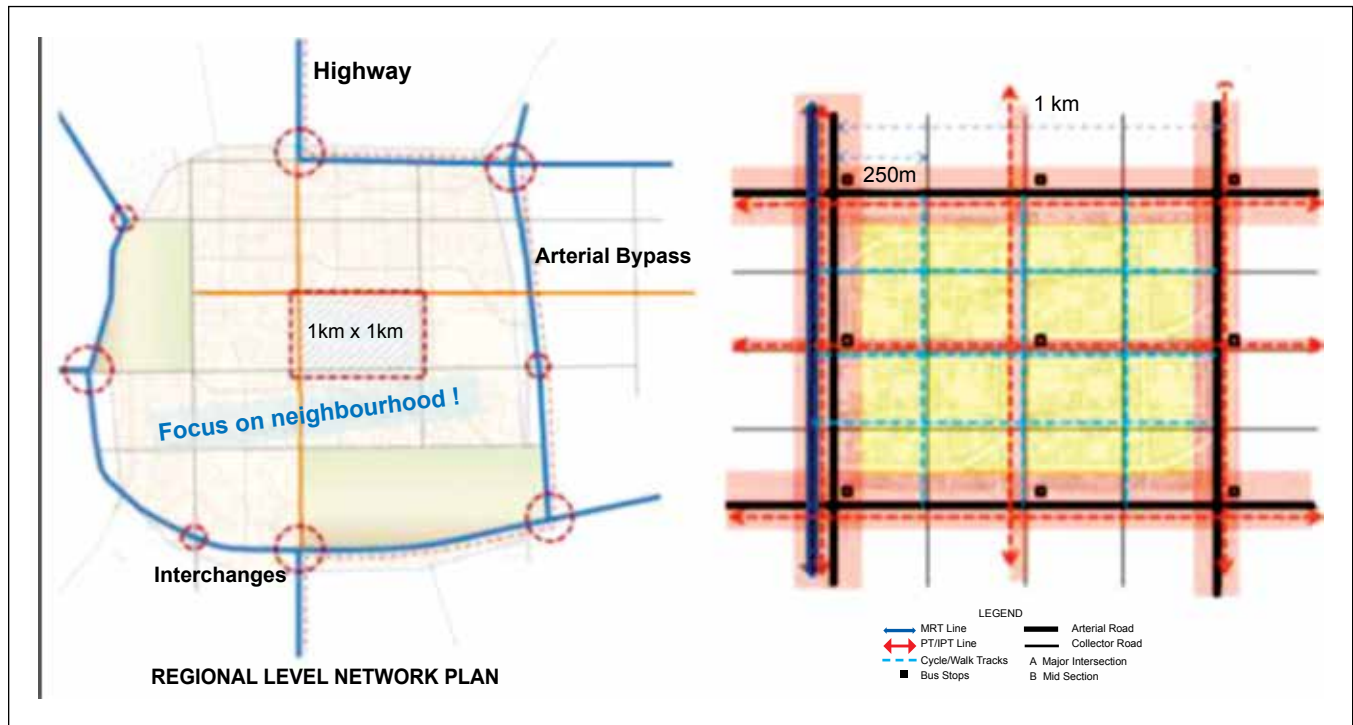


Fig. 15 Grid Urban Road Network System

- **Arterial Roads:** Arterial roads form the primary road network and carry passenger and goods traffic connecting all major city level land use activity areas. Arterial roads shall provide distinct and segregated movement space for motorized and non-motorized modes/pedestrians along with all functional supportive street elements.
- **Mass Rapid Transit:** Arterial and sub-arterial roads may have future provisions for high capacity transit system (Metro/BRT etc.) with inter modal transfer facilities along with physical and operational integration of multi modal system.
- **Minimal Disruption to Existing Environment:** Road networks/alignments need to be planned with minimum disruption to existing settlements/structures, fertile and environmentally sensitive areas (lakes, mangroves, flood zones).

3.5 Principles of a Pedestrian Network

- **Complete Segregation on all Roads:** Physical segregation of pedestrians from the vehicles on the road is an important aspect to ensure pedestrian safety in

urban areas. Importance of segregation should not be limited to providing only footpaths all along the road but should also include safe crossings on streets at strategic locations with various traffic control measures like traffic signals, road signages and markings.

- **Retrofitting of Existing Network:** The retrofitting of existing roads shall follow the mode priority outlined in **Fig. 2** and be designed as complete streets for each road category.
- **Encroachment-free Footpaths with Universal Accessibility:** Footpaths should be continuous and barrier free for safe and comfortable movement by elderly, children and persons with disabilities (PwDs) and other users including street vendors, who provide affordable goods and services for pedestrians and non-motorized vehicles.
- **Shared Local Streets with Traffic Calming Measures:** Local streets, where pedestrians share the road space with other vehicles, must be traffic calmed. In case footpaths are not provided, it should have traffic calming measures to control the speed of vehicles to less than 20 kmph.
- **Active Streets:** Streets where building edges/frontages are oriented toward and directly accessible from the street on foot to promote pedestrian activity. Two major aspects to be considered to transform a city street into an active street.
 - Create “eyes on the street” – by removing setbacks and boundary walls and building to the edge of the street right of way. This would allow people from inside to look out on to the pavement, thus enhancing women and girls’ safety security and discouraging criminal activities, misbehaviour, shady corners, etc.
 - Create commercial/hawking zones at regular intervals to encourage walkability, increase street activity and enhance safety.
- **Pedestrianized Streets/Plazas/Squares:** In addition to a closed grid network in residential and commercial centres with provision for adequate and barrier free footpaths and active streets, car free pedestrian streets and plazas shall be considered for retail streets, market streets, and feeder streets to mass transit stations or inner-city areas.

3.6 Principles of a Non-Motorized Vehicle Network

Non-motorized vehicles offer low-cost, pollution-free mobility. Cycles occupy only one-fifth as much driving and parking space as automobiles. Due to lack of physical separation from motorized vehicles, non-motorized vehicles face inconvenience and safety hazards from faster moving traffic. Where motor vehicle lanes are saturated, cycling in a segregated track is often faster and safer than using a private motor vehicle. Good cycle tracks are continuous and provide for uninterrupted movement (**Fig. 16**).

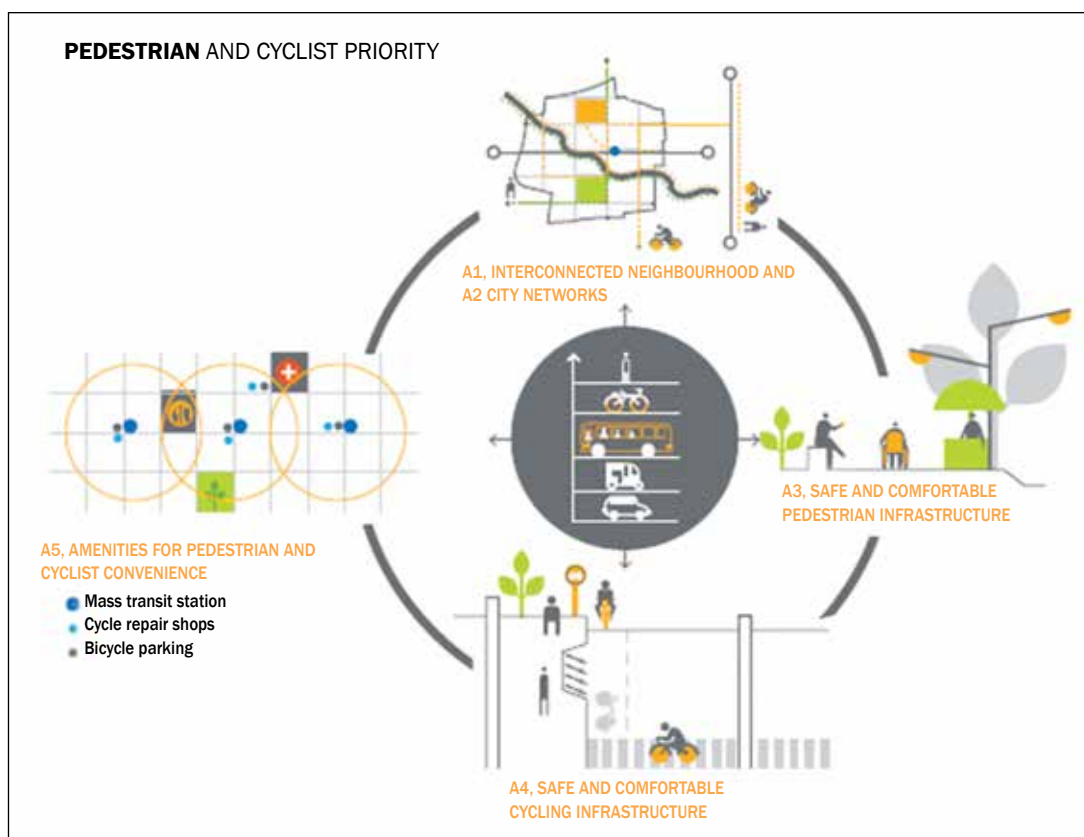


Fig. 16 Pedestrian and Cyclist Priority

- **Segregated and Continuous Non-Motorized Vehicle Network:** Apart from segregated two-way cycle/non-motorized vehicle track on all arterial and sub-arterial roads, a non-motorized vehicle network may be developed at zonal/neighbourhood level and connected to non-motorized vehicle corridors on arterial roads for a continuous city level non-motorized vehicle network.
- **Smooth Riding Surface:** The non-motorized vehicle tracks shall have a smooth surface. Paver blocks are discouraged. Further, proper drainage of storm water shall be ensured to prevent water logging.
- **Barrier Free Non-Motorized Vehicle Tracks:** Non-motorized vehicle tracks shall be free of obstructions such as manhole covers and on-street parking encroachments.
- **Redesigning Junctions and Mid-Block Crossings:** Existing intersections and mid-block crossings shall be redesigned with signages and road markings to ensure safe crossing paths for non-motorized vehicles.
- **Traffic Calming Measures:** Speed of traffic on all shared streets shall be reduced to less than 20 kmph through traffic calming elements.

3.7 Principles of a Public Transport Network

- **Integrated Road and Transit Network System:** A road network system defines the public transport accessibility level such that people can access it within 500 m walking distance. The arterial corridors provide for high capacity multi modal transit system and physical integration through interchange facilities (**Fig. 17**). The bus stands/

terminals, bus stops with adequate space provisions with amenities for passengers are critical requirements and need to be incorporated in secondary road network plans.

- **Enhanced Public Transport Accessibility:** The enhanced use of public transport largely depends on universal accessibility, frequency of service, travel time, comfort and travel cost. Public transport service frequency and quality improvement should receive consideration of the state/city government for reduction of road congestion, optimum utilisation of road network, improvement of air quality and efficient energy use.
 - Bus stops should be located 40-45 m distance from the pedestrian crossing points of an intersection to facilitate access.
 - Stands for all intermediate public transport/last mile connectivity modes (auto-rickshaws, cycle rickshaws, cycle sharing, e-rickshaws) should be located in the multi-functional zone within 12-15 m distance of the bus stops.
- **Optimum Utilisation of Road Space:** Exclusive bus corridor on arterial roads and bus lane marking on secondary road system without any encroachment by other modes will ensure orderly and smooth movement of traffic on road carriageway. This will also ensure optimum utilisation of road space and also enhance the carrying capacity of traffic.

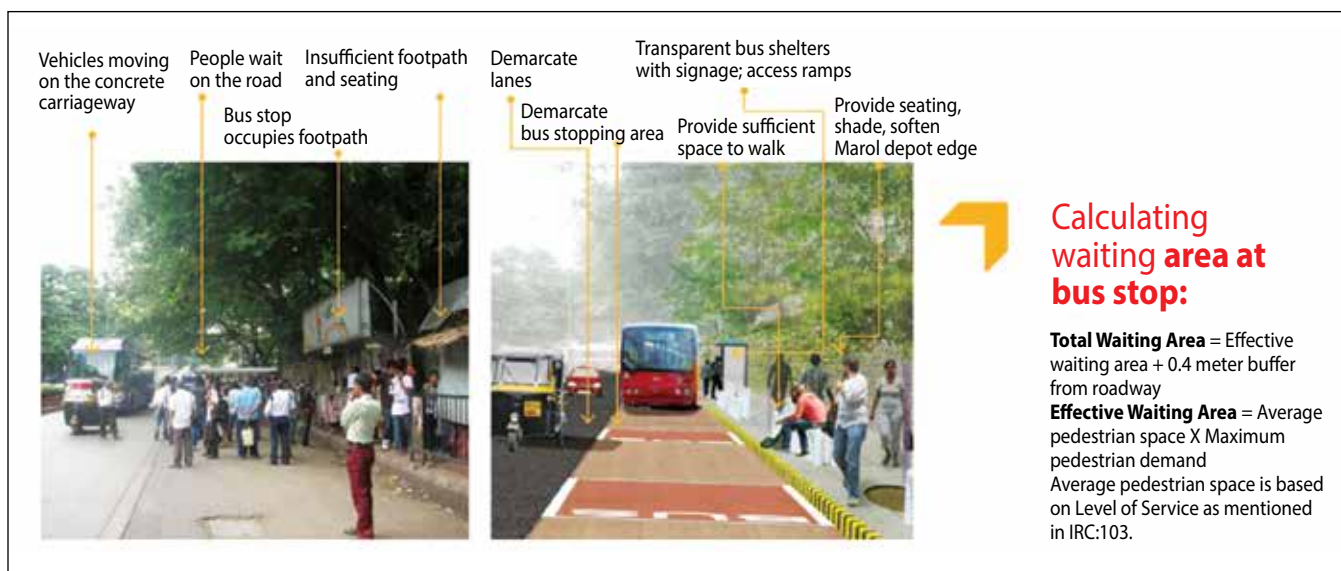


Fig. 17 Existing and Redesigned Bus Shelters in Mumbai

3.8 Multi-modal Integration

Multimodal transportation system is the integration of various modes of travel – bus rapid transit, city bus, metro, light rail transit, monorail, walking and cycling for better, advanced and efficient service (Fig. 18). Particularly, in the vicinity of 500 m of mass transit stations, multi-modal integration includes:

- Minimizing travel time and cost for majority of commuters by providing multiple mode options for all sections of society with safety and affordability. Minimize the number and the time required for mode transfers for maximum commuters.

- Prioritizing safe pedestrian and cycling access to mass rapid transit.
- Providing seamless integration with feeder modes and intermediate public transport services.
- Creating an enhanced public realm for people.

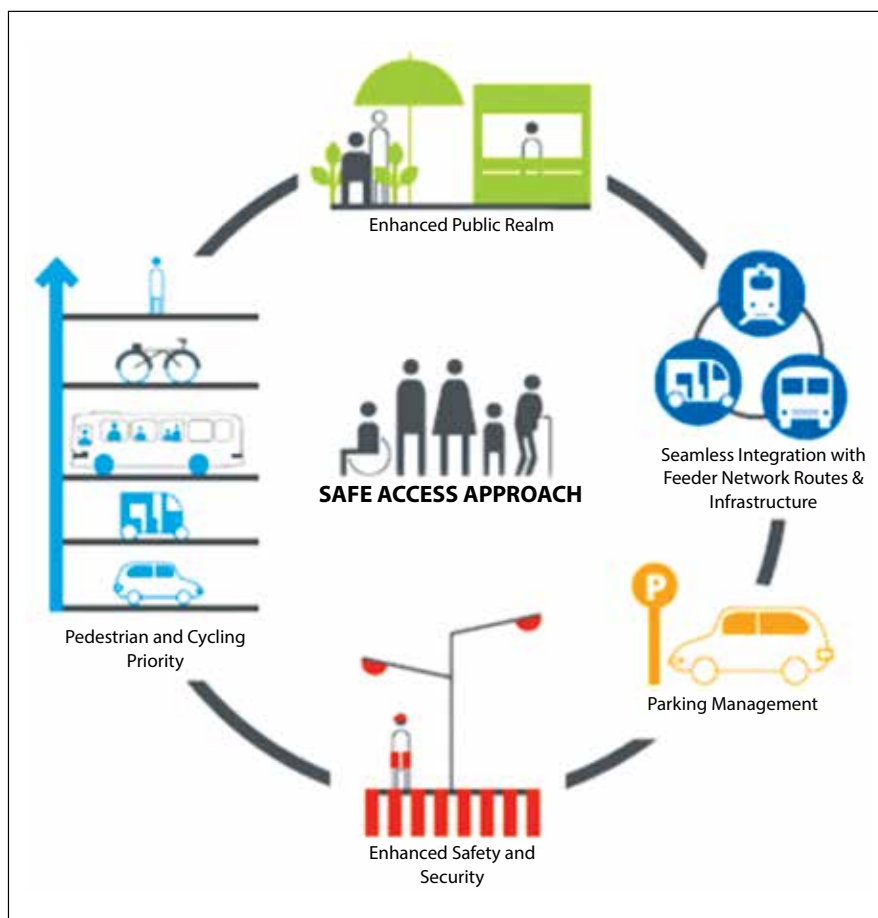


Fig. 18 Safe Access to Mass Transit Stations

The integration of various modes around entry/exit of mass transit stations may adopt the checklist given in **Table 3**.

Table 3 Recommended Distance of Various Facilities from Entry/Exit of Mass Transit Station

S. No.	Walking distance from the station exit	Facility/amenity and preferred location
1	Within 50 m	Bus stops, vendor zones, cycle-rental stations, cycle parking stand, public toilets
2	Within 100 m	High occupancy feeder stop/stand
3	Within 150 m	Cycle-rickshaw stand, other intermediate public transport/auto-rickshaw stand
4	Beyond 150 m	Private car/taxi “drop-off” location only (No parking)
5	Beyond 500 m	Off-street car parking facility should be discouraged. It may be considered in case of pedestrianization of streets and only after an on-street parking management system has been implemented.

- **Feeder and Shared Mode Corridors:** Shared intermediate public transit is functional in many cities and is the main form of public transit in small and medium sized cities. In large cities, they should be organised with necessary route mapping and stand locations to provide 500 m last mile connectivity. Rickshaw as a non-polluting, energy efficient intermediate public transport mode has tremendous potential to reduce private motor vehicle use for short intra and inter colony movements apart from providing access to metro/bus rapid transit stations in future. The collector and local road network should be the natural routes of operation to provide short distance low fare travel option. In small and medium sized cities, sheltered stops/stations should be provided for commuters, and where possible, their routes and frequencies should supplement a well-planned public transit service.
- **Transit Interchange Hubs:** The guidelines given below maybe adopted for integrated passenger and bus terminals.
 - All such terminals should have preferably collector/sub arterial roads on two sides of the plot to facilitate entry and exit of buses and other modes.
 - In case of approach from one side, two separate entry and exit to the road to be provided for vehicles. Separate entry and exit for pedestrians/passengers from the road should be provided for safety of passengers.
 - All boarding and alighting of passengers should be within the terminal area only and no overspill on the road should be allowed.
 - City bus stop should be within 100-200 meters from the terminal entry/exit with a clear pedestrian link with the terminal.
 - No service road along the terminal to be provided to avoid misuse by illegal parking/stands etc.
 - Proper organised space for parking/stand of intermediate public transport vehicles and vendors should be provided to facilitate transit passengers.

3.9 Principles for Intersections, Interchanges and Traffic Rotaries

One of the major challenges in creating dense, well-connected networks is the design and planning of frequent junctions along major arterial roads. The following strategies can be adopted at intersections to enable safe non-motorized transport crossing, while facilitating vehicular movement:

- Synchronization of signals (e.g. all pedestrian lights on one side of the road to be green when primary vehicular flow is red, etc.)
- Pelican signals at pedestrian/non-motorized vehicle crossings with median islands for pedestrians waiting halfway through the crossing, with universal access.
- Raised crossings for pedestrians and non-motorized vehicles.

For design guidelines and standards of intersections and interchanges, refer IRC:SP:41 and IRC:92 respectively. For design guidelines for traffic rotaries, refer IRC:65.

3.10 Principles of Parking Management

The use of Personal Motor Vehicles (PMVs) shall be effectively managed by implementing a formal parking management system:

- A parking management system shall be devised to promote sustainable modes of transport, price on-street parking to manage demand, improve the enforcement of no-parking zones and keep personal motor vehicles from obstructing non-motorized facilities.
- Parking and no-parking zones shall be clearly demarcated. Footpaths, cycle tracks, and other non-motorized transport facilities will be designated as no-parking zones. **Fig. 19** illustrates a proposed hierarchy of parking provision.
- The Traffic Police shall ensure that footpaths, cycle tracks, and other non-motorized transport facilities remain free of encroachment by parked vehicles.
- The revenue collected from the parking management program may be utilized to fund public transport and non-motorized transport improvements.

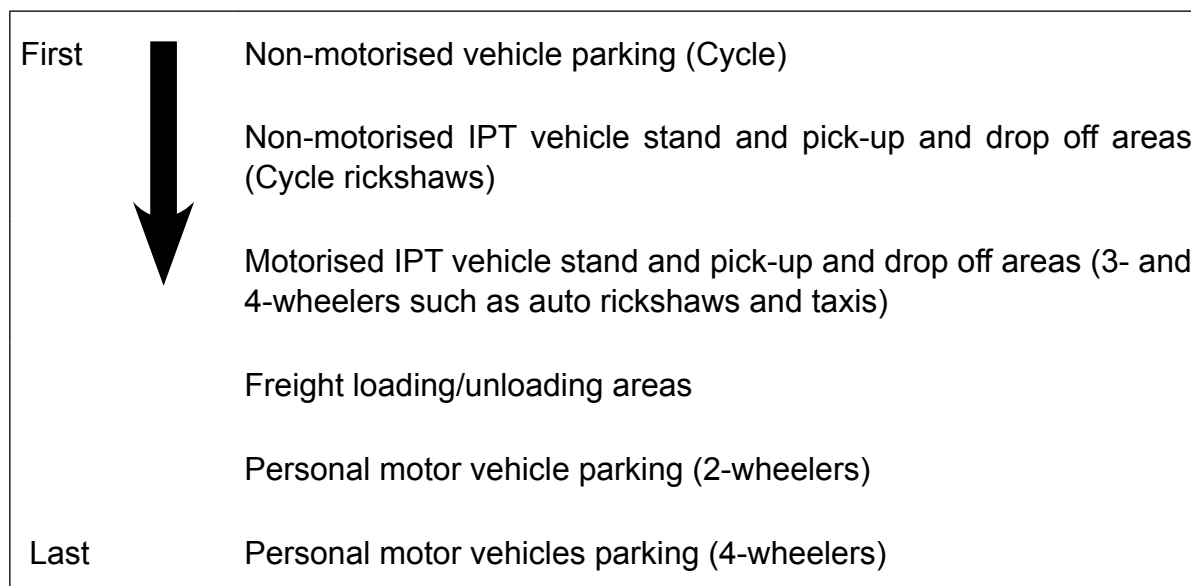


Fig. 19 Hierarchy of Parking Provision

3.11 Principles of Street Vending Management

Street vending shall be managed in accordance with the provisions of the National Street Vendors (Protection of Livelihood and Regulation of Street Vending) Act 2014 and relevant state rules:

- Street vending shall be regulated to ensure the continuity of footpaths and cycle tracks.
- Existing culturally significant street vending markets shall be preserved.
- Supportive infrastructure such as water taps, electricity points, waste bins, and public toilets shall be provided.

CHAPTER 4 ACCESS MANAGEMENT

4.1 Access Management Principles

The following principles may apply for access management on roads and streets in urban areas:

- Where service roads are provided, arterial roads should not have a direct vehicular access to any plots or building from the road.
- Larger plots with off-street parking facilities should be accessed from the side road. For smaller plots, parking should be unbundled and provided at strategic parking plots.
- All plots shall have pedestrian and cycle access directly from footpath and cycle track or service road along arterial roads.

4.2 Service Roads

Service roads improve safety and throughput by segregating property access points and parking from the main carriageway. They can increase the mobility function of the main carriageway while also maintaining liveability and smooth travel for non-motorized road users. With reduced speeds because of traffic calming, service roads can function as slow shared spaces.

Service roads should facilitate access to properties, discourage through movement and create a safe environment for pedestrians and non-motorized vehicles. However, it is difficult to maintain priority for pedestrians and non-motorized vehicles on service lanes that are wide enough for two-way car movements at high speeds.

4.2.1 *Design Principles and Standards*

- The need for a service road along an arterial road is determined by right of way and the frequency of property access points. If property access points would interrupt the footpath and cycle track at frequent intervals (more than once every 15 m), a service lane may be warranted.
- The position of the footpath relative to a service road shall be determined by the character of the private property edge. If the street is lined by boundary walls or setbacks used for vehicle parking, the parking lane should be located at the edge of the right-of-way and the footpath on the carriageway side of the service road. Such a design is also appropriate if activities on adjacent properties spill over into the public right-of-way.
- In residential areas where there is a porous boundary between the street and private properties, the footpath can be placed on the property side. Likewise, in retail areas where there are no setbacks and buildings open directly onto the street, the footpath should be located at the edge of the right-of-way.

- Loading and unloading of goods and on-street parking may be accommodated within the multi-functional zone of the footpaths. Access into and out of a service road should be provided via a ramped crossing over the footpath and cycle track, which continue at original levels. **Fig. 20** gives a broad idea of location of footpath relative to service lane.

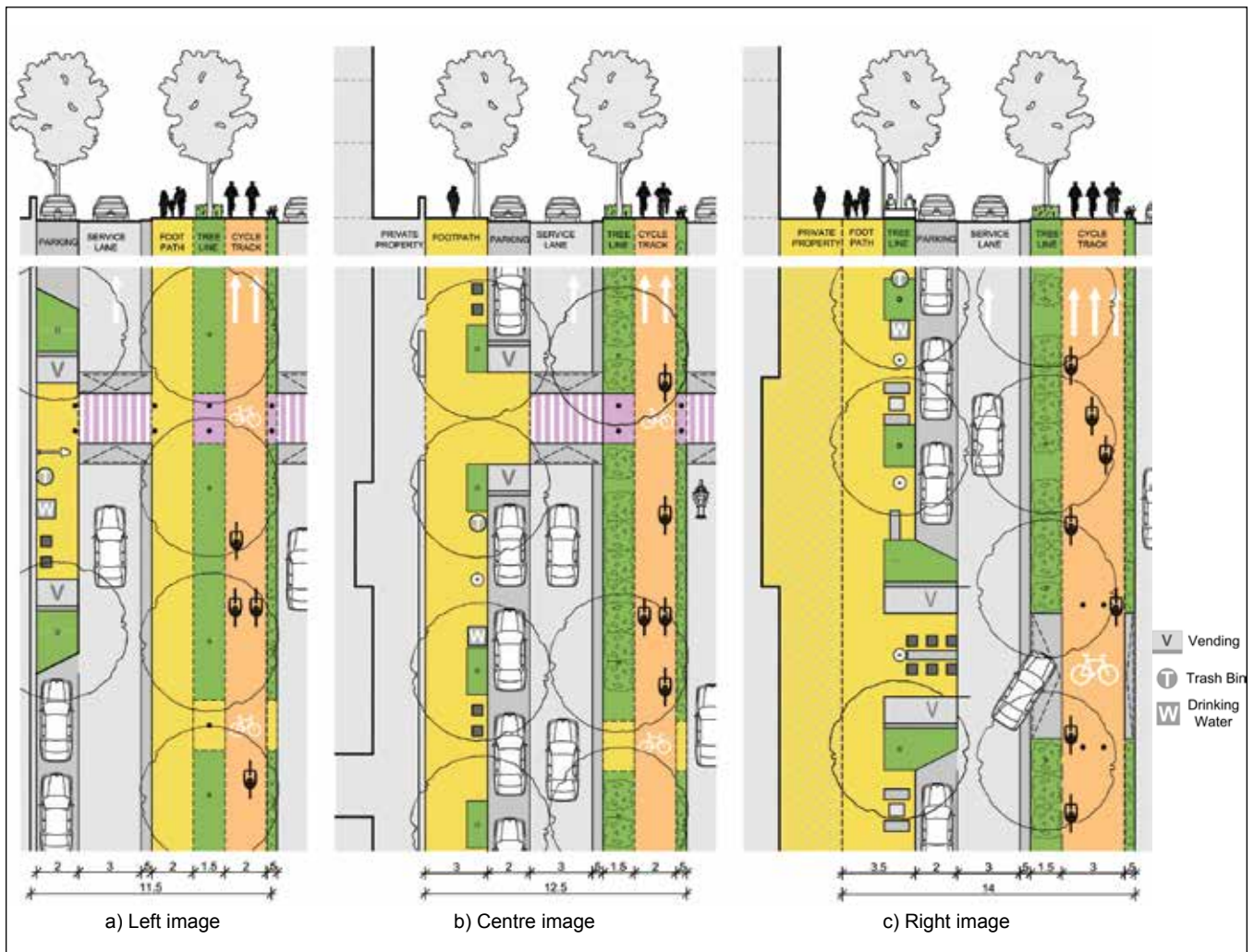


Fig. 20 Location of Footpaths Relative to Service Lane

Left image: When the road stretch is predominantly lined by high and opaque boundary walls (>1.2 m), the footpath should be located between the service lane and the cycle track/carrageway.

Centre image: When the road stretch is predominantly lined by boundary walls less than 1.2 m height or allow visual connectivity, the footpath may be located on the outer edge so that it can promote liveability and interaction between public and private open spaces.

Right image: Adjacent to active commercial edges, the footpath may be located on the outer edge, where it can combine with private building plazas to create larger pedestrian spaces.

CHAPTER 5 STREET DESIGN AND IMPLEMENTATION PROCESS

5.1 Vision Statement

The goal of a street design process is to create complete streets to enable safe, comfortable and convenient access for all road users, address social concerns, promote environmental sustainability and reduce the impact on the natural environment, while creating vibrant and liveable public spaces. The design of urban streets promotes a collaborative and consultative process enabling professionals of different disciplines to work together to maximize the efficacy and long-term success of the same.

5.2 Institutional Framework

Street Design Cell

A Street Design Cell may be created within road departments of Urban Local Bodies (ULBs), para-statal agencies and Public Works Department to develop comprehensive street design network plan for the city, review and monitor the street design and implementation process, arrange capacity building and training for technical and other personnel of the road department. This cell should also be involved in community engagement and advocacy. It shall include professionals to facilitate the above roles – urban and transportation planners/geographers, urban designers, landscape architects, traffic and civil engineers, GIS (Geographic Information System) specialists and external consultants advising on social and environmental safe guards, road safety, universal accessibility and women’s safety and security. The suggestive roles and responsibilities of the Street Design Cell are outlined in **Annexure 1**.

Co-ordination Committee

The successful implementation of street design projects will involve cooperation between multiple stakeholders, such as urban local bodies, traffic police, town planning agencies, consultants and others, at different stages. The urban local bodies may like to set up a Review Committee and convene regular meetings to oversee street design proposals produced by consultants, implementation and monitoring as well as to address inter-agency issues that may arise during this process. The Committee may include the following members:

- Officials from the Municipal Corporation, such as,
 - Head of the Street Design Cell,
 - City Engineer,
 - Zonal Engineers,
- Representative from public transport agencies,
- Representative from traffic police,
- Representative from local town planning or development authority,

- Representative from non-government or community organisations
- External experts

Stakeholder Consultations

Stakeholder consultations may be organized in the form of charrettes, exhibitions and town halls during the conceptual design stage. Stakeholders can be characterized as primary, secondary and key.

- Primary stakeholders are beneficiaries and include commuters, residents, resident welfare associations (RWAs) etc.
- Secondary stakeholders are people or groups who are indirectly affected. These may include those who offer services to the target groups, or whose jobs may be affected by the street design. These include auto-rickshaw or taxi drivers, street vendors, private bus operators, business owners and their groups.
- Key stakeholders are those who can frame and enforce regulations or implement projects. These include local or state government agencies, elected representatives like Corporators, Members of Parliament or Legislative Assemblies, businesses, etc.

5.3 Design Process for Existing Streets

The street design process for existing roads is shown in **Fig. 21**. The process for road networks in new cities or urban extension areas is outlined in **Annexure 2**.

5.3.1 Study Zone

The road or intersection identified for improvement shall be part of a larger study area within 1 km radius of its right of way. If a local street is to be improved, the study area shall include a 500 m radius from its right of way. The boundary of the study area shall be along plot boundaries, wherein 50 percent or more of property falls within this radius.

A base map of the study area will be prepared to include the road network, right of way, hierarchy, existing traffic management systems, existing and proposed public and mass transit facilities, intermediate public transport stands and plot and building details such as plot boundaries, building footprints, building heights and uses and major activity generators and attractors.

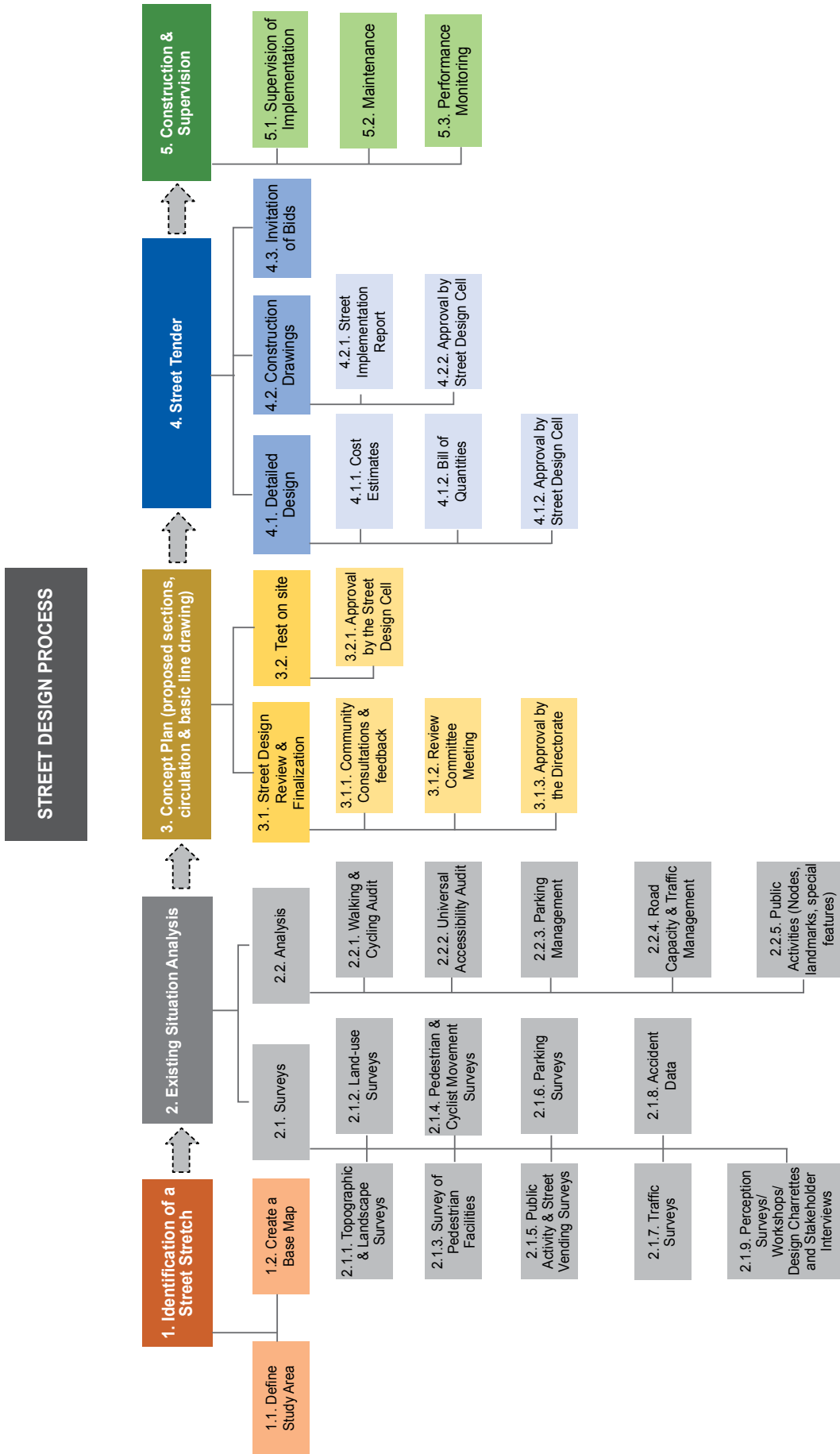


Fig. 21 Design and Implementation Process for Existing Streets

5.3.2 Analysis of Site Situation

5.3.2.1 Type of surveys

Table 4 Types of Surveys

Sl. No	Survey	Applicability	Survey Specifics
1	Topographical and landscape surveys (Example Fig. 22)	<ul style="list-style-type: none"> • Along the road stretch and all streets at least up to 50 m from intersections. • Establish temporary Bench Mark (BM) stations at least one in every 300 m intervals. These stations and all levels shall be connected to Survey of India, GTS datum or any other location • Base map should be in Auto CAD format with each element to be provided in a separate layer. 	<ul style="list-style-type: none"> • Topographical surveys are carried out using DGPS (Differential Global Positioning System), Total Station, LiDAR (mobile or terrestrial) or Unmanned Aerial Survey (UAV). • Swath of survey should cover the entire width of right of way at every 15 m interval and include all street elements such as footpaths, cycle tracks. • Carriageway at every 15 m interval with existing bituminous/concrete portion width. • Difference in levels wherever it occurs. • Cross section level at every 30 m in plain and rolling terrain. Hilly terrain data to be collected at closer intervals. Height of footpath at every 15 m intervals. • Bus shelter structure, bus stops, intermediate public transport stops. • Footpaths/pathways including all kerbs and level differences. • Locations of zebra crossings, mi-block crossings. • Signals/road signages. • Intersection elements. • Features of roundabouts. • Medians/bollards/permanent barricades. • Compound walls and each access point/gate.

Sl. No	Survey	Applicability	Survey Specifics
			<ul style="list-style-type: none"> • All overhead utilities (electricity, telephone, street lights, surveillance camera etc.) poles/boxes, manhole covers, high tension and low tension transmission lines along with their capacities, water hydrants, transformers. • Street furniture. • Trees to be indicated in two categories: One Category width of girth 30 cm and above and the other category width of the girth less than 30 cm. The girth to be measured at 1 m height from the ground level. • Front facade of existing buildings/ structures. • Location, size, height (above finished road level) and invert levels of storm water drains (covered and uncovered). • Underground utilities - service lines/cable ducts for electricity, sewer, water supply, storm water drains, telecommunication etc. • Culverts and bridges, flyovers/grade separators. Swath of the surveys (90 m) will be more than the right of way at major and minor bridges. • Panoramic photo documentation may be carried out at every 30 m interval for plain areas and rolling terrain (and closer interval hilly terrains).
2	Land-use surveys	<ul style="list-style-type: none"> • All buildings within the study area 	<ul style="list-style-type: none"> • Survey plots, building footprints, heights. • Survey must include building uses of ground and first floors adjoining the street to identify important activity generators on the street, such as shopping areas, theatres, and housing developments. • All data should be recorded using a GIS (Geographic Information System) platform or AutoCAD.

Sl. No	Survey	Applicability	Survey Specifics
3	Pedestrian and cyclist movement surveys (Example Fig. 23)	<ul style="list-style-type: none"> • Counts at key intersections and mid-block crossings of the road stretch and all streets up to 50 m from intersections. • Understand broad pedestrian and cyclist movement within the study area using line drawings. 	<ul style="list-style-type: none"> • The number of pedestrians and cyclists / cycle rickshaws using the streets over 16 hours on a normal working day, including peak hours. • Tracking survey of pedestrian crossing movements at important intersections along each street and depicted using line drawing. • The presence of shade between 1-3 pm to be recorded from buildings or trees on street. • Road markings, types of signage such as no entry, U-turn, silent zone signs etc. to be recorded.
4	Public transport use	<ul style="list-style-type: none"> • Existing demand and supply of public transport services. 	<ul style="list-style-type: none"> • Demand and supply of public transport services. • Quality of public transport infrastructure.
5	Public activity and street vending surveys (Example Fig. 23).	<ul style="list-style-type: none"> • Along the road stretch and all streets up to 50 m from intersections. 	<ul style="list-style-type: none"> • Identify and map the active public spaces, nodes, landmarks within the study area. • All the vendors along the road stretch must be noted and whether the vendor is stationary or mobile. • The survey should note whether the vendor is an obstruction to pedestrian and cycle movement. • Location of social gathering spaces in the public right of way, as well as the number of people engaged in activities in such spaces in the study area. This information will help in identifying the placement of street furniture and other elements in the final design.
6	Parking surveys	<ul style="list-style-type: none"> • Road stretch and along roads within 500 m of all intersections. 	<ul style="list-style-type: none"> • A parking survey must be carried out to identify parking patterns and occupancy rates. • Parking demand should be established by a manual count, classified by vehicle type, informal/formal.

Sl. No	Survey	Applicability	Survey Specifics
			<ul style="list-style-type: none"> • The survey should cover on-street parking areas as well as off-street public or semi-public parking. • The survey shall be conducted for three hours during morning peak and three hours in the evening peak period in such areas. • Parking pricing and their variation - hourly, weekly and monthly charges shall be noted by vehicle type. • The extent of the parking zones to be studied must be approved by the city administrator. • All parking data should be recorded using the GIS (Geographic Information System) platform or AutoCAD.
7	Traffic surveys at interactions	<ul style="list-style-type: none"> • Traffic counts along major intersections. • Traffic movement patterns in the study area. 	<ul style="list-style-type: none"> • Traffic counts of motorized vehicles from over 16 hours must be conducted over peak and off-peak hours in any typical working day (one day). These must be coterminous with the timings of the non-motorized transport counts. • They must be categorized under buses, heavy commercial vehicles, light commercial vehicles, auto-rickshaws, cars/jeeps and two-wheelers. • Existing traffic movement and management measures: one-way, signals, U-turns, time restrictions and so forth. • Signal timing and phasing survey includes (a) signal cycle time: time required to complete the sequence of signal directions (b) signal phase: Is the part of a cycle allocated to any combination of traffic movements.

Sl. No	Survey	Applicability	Survey Specifics
			<ul style="list-style-type: none"> • Queue length survey is to be conducted at identified signalized inter-sections to measure the queue length of all approaching arms of the inter sections during peak and off-peak hours. • Saturation flow data at signalized intersection.
8	Accident Data	<ul style="list-style-type: none"> • Along the road stretch and within 50 m of all intersections. 	<ul style="list-style-type: none"> • Collect data on accident hot spots from the Traffic Police. • Develop and implement system of reporting of accidents to police and the city engineer of the Urban Local Body.
9	Perception Surveys/ Workshops / Design Charrettes and Stakeholder Interviews	<ul style="list-style-type: none"> • Residents, visitors, formal and informal businesses and service providers along the road stretch. • Pedestrians, cyclists, public transport commuters, intermediate public transport users along the road stretch. 	<ul style="list-style-type: none"> • Perceptions of different users on their experience of using the road/street and suggested improvements. • Workshops and design charrettes can be organized to involve local stakeholders and understand their concerns and expectations from the project and urban road network. • Stakeholder interviews with Zonal Traffic Police, Roads Department, Resident Welfare Association, Industry Associations and Utility Providers.

5.3.2.2 Secondary data

In addition to the surveys, secondary information from ongoing and proposed projects (published or unpublished data) for the road stretch shall be collated and analysed. The data include may public or mass transit improvements, road widening proposals, beautification projects within the study area likely to impact the road stretch.

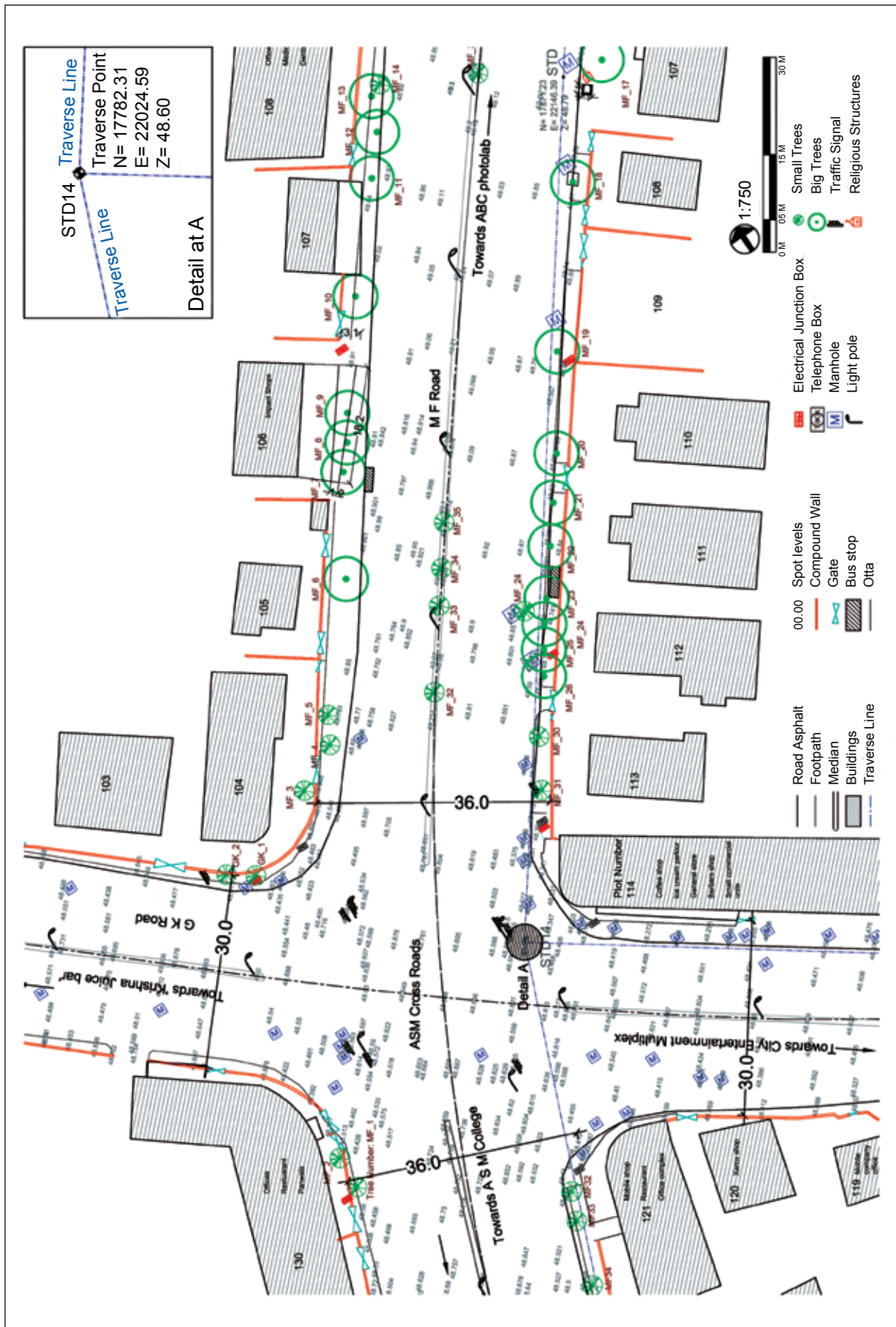


Fig. 22 Example of Topographic Survey

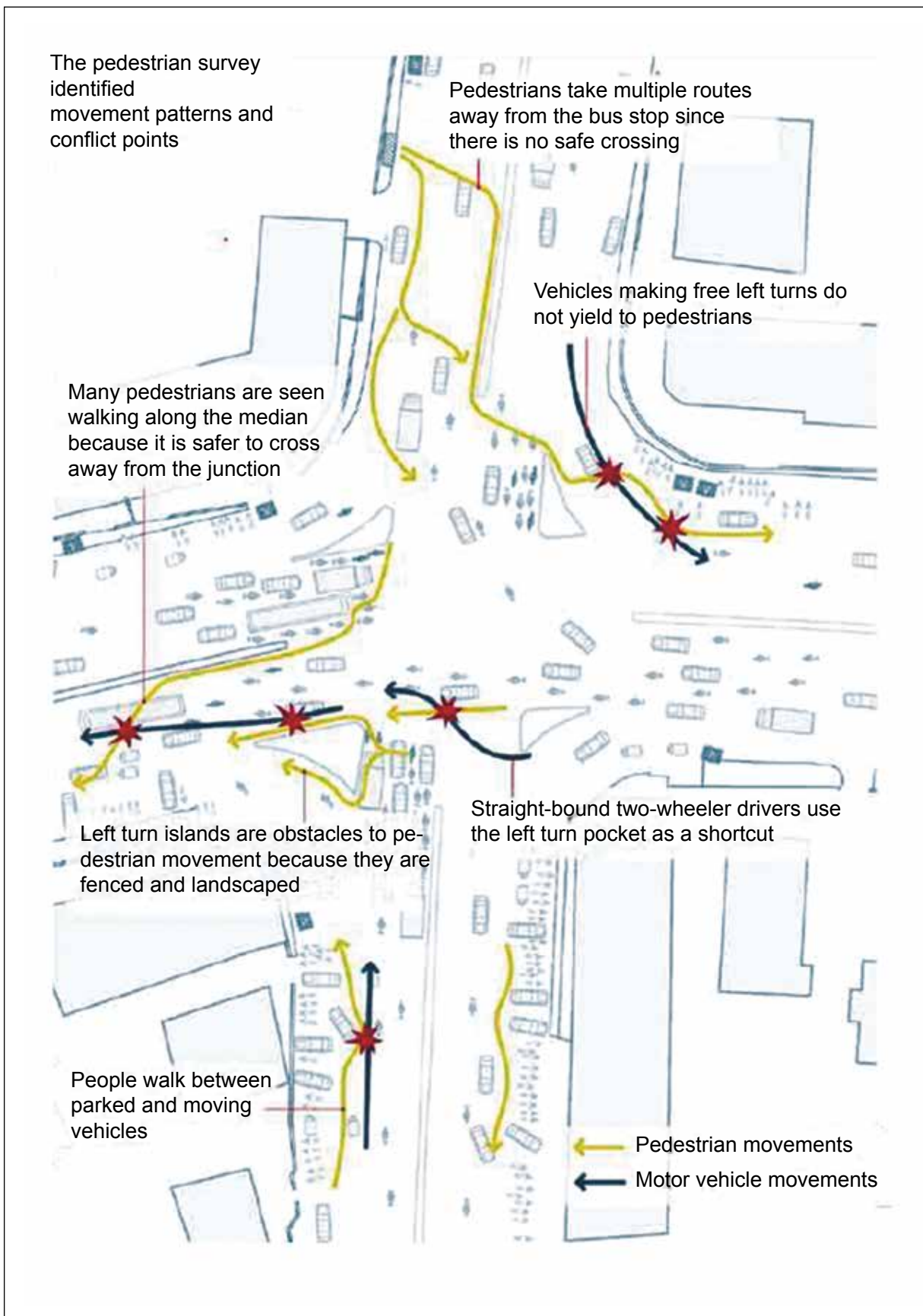


Fig. 23 Pedestrian Movement and Conflicts

The activity survey revealed a concentration of food vendors and customers at the main intersection during evening hours.

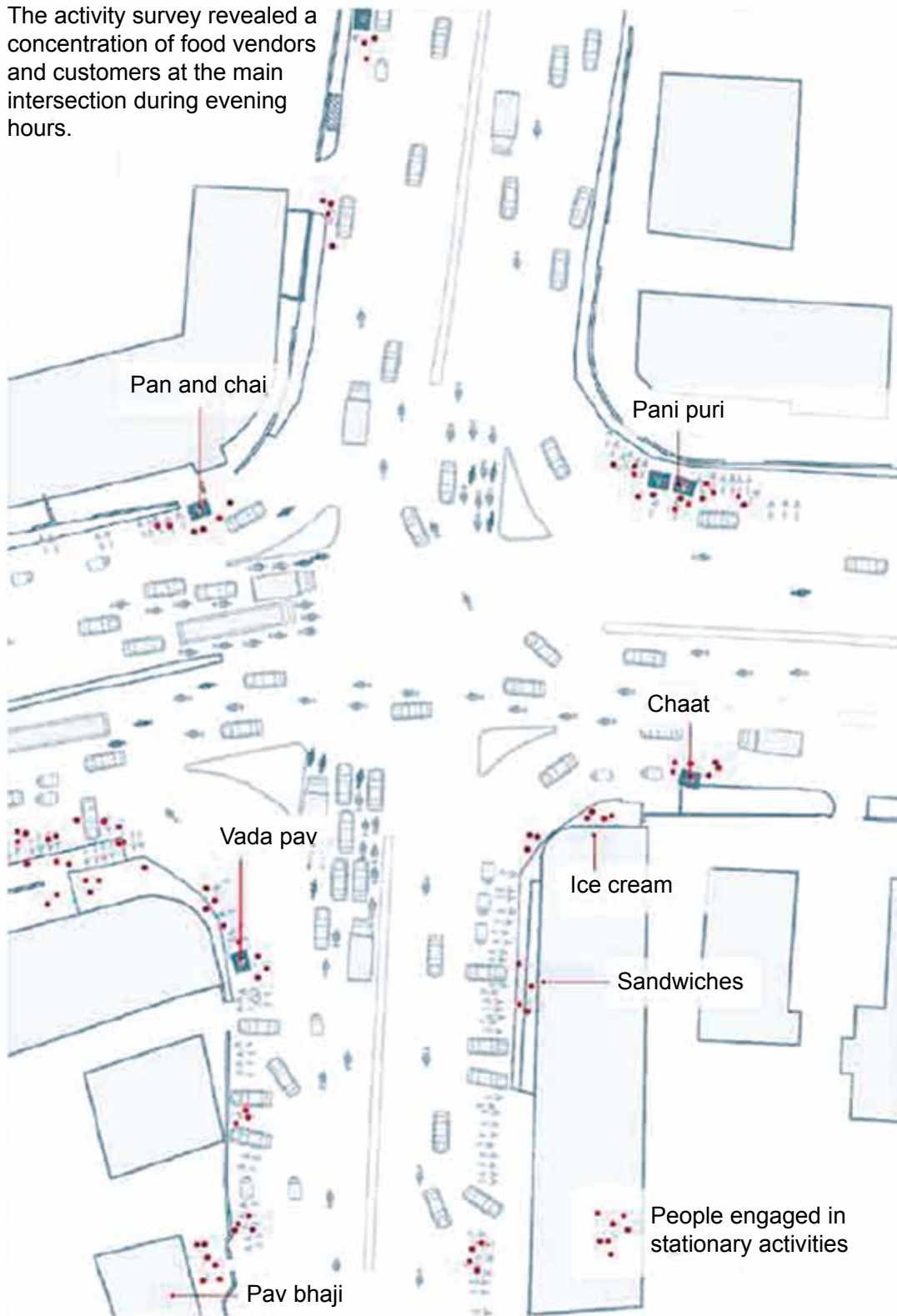


Fig. 24 Activity Surveys

5.3.2.3 *Analyses and proposals***Table 5 Analyses and Proposals**

Sl. No	Type of Analysis	Details	Plans
1	Walking and Cycling Assessment	<ul style="list-style-type: none"> • Assess the availability and existing levels of service of pedestrian infrastructure, height and surface of footpaths, crossing opportunities, availability of shade, obstructions and availability of street furniture • Assess the provision of public and intermediate public transport infrastructure, level of service for waiting, access ramps, signage and shade; integration with other modes to minimize conflicts • Assess the availability, level of service of existing cycling infrastructure, (where applicable), surface continuity, obstructions, shade and services. 	<ul style="list-style-type: none"> • Pedestrian Movement and Issues Plan • Cycling Movement and Issues Plan • Proposed Pedestrian and Cycling Plan
2	Universal Accessibility Assessment	<ul style="list-style-type: none"> • Identify barriers and obstacles in using existing roads/streets by women, children, elderly, persons with disabilities– wheel chair users, persons with limited hearing and sight 	<ul style="list-style-type: none"> • Plan identifying issues and proposals for women and children, elderly, persons with disabilities
3	Parking Management	<ul style="list-style-type: none"> • Existing occupancy, demand, obstruction of walking and cycling infrastructure or inhibiting movement of vehicular traffic and need for an on-street parking management system 	<ul style="list-style-type: none"> • Parking Issues and Management Plan
4	Road Capacity and Traffic Management	<ul style="list-style-type: none"> • Existing traffic movement and management issues such as signaling, U-turns, parking obstruction • Existing and proposed improvements to public and mass transit facilities • Need for augmenting passenger capacity of the roads through provision or upgrading bus services and other measures 	<ul style="list-style-type: none"> • Traffic Movement and Management Plan • Public Transportation Plan

Sl. No	Type of Analysis	Details	Plans
5	Activities	<ul style="list-style-type: none"> Assess different types of activities including street vending at different times of the day and the demand for street furniture 	<ul style="list-style-type: none"> Public Space and Activities Plan
6	Road Safety Inspection	<ul style="list-style-type: none"> The survey must cover all streets in the study area plus any intersecting streets Site Visits are conducted covering various conditions: daylight, darkness, peak and off-peak hours Inspectors travel in all directions and focus on Road signages and markings, Junctions and path crossings, Sight distances, Fixed objects, Illumination and Destinations 	<ul style="list-style-type: none"> Road Safety Inspection Report with at least one recommended solution to each identified issue

5.4 Proposed Concept Plan

5.4.1 *Choosing a standard street section*

A standard street section must be selected in keeping with the provisions of the city's Street Design Guidelines and RoW available. The design should be consistent with relevant plans, including plans for Bus Rapid Transit (BRT) networks, cycling networks, pedestrian networks, and pedestrian zones. This section must be then contextualized to different stretches.

5.4.2 *Line drawing*

A line drawing must be developed based on selection of suitable right of way and subsequent traffic lanes must be offset to create kerb lines (See **Fig. 25**). However, it must be ensured that the clear width of footpaths does not fall below the minimum specified as per Pedestrian Facilities (IRC:103). Based on this, the position of major elements such as parking bays, trees, and bus stops can be determined along with the placement of street furniture.

Line drawings must be prepared for the road stretch and up to 50 m from the intersections along the road. Line drawings must clearly show the new kerb line in reference to the road median. The drawing must be complete with dimensions at 2 m intervals. Cross-sections may be prepared at every 50 m. Further, 3D models or visualisations of the proposed design may be prepared as these will be useful at stakeholder meetings and discussions see **Figs. 26 and 27**.

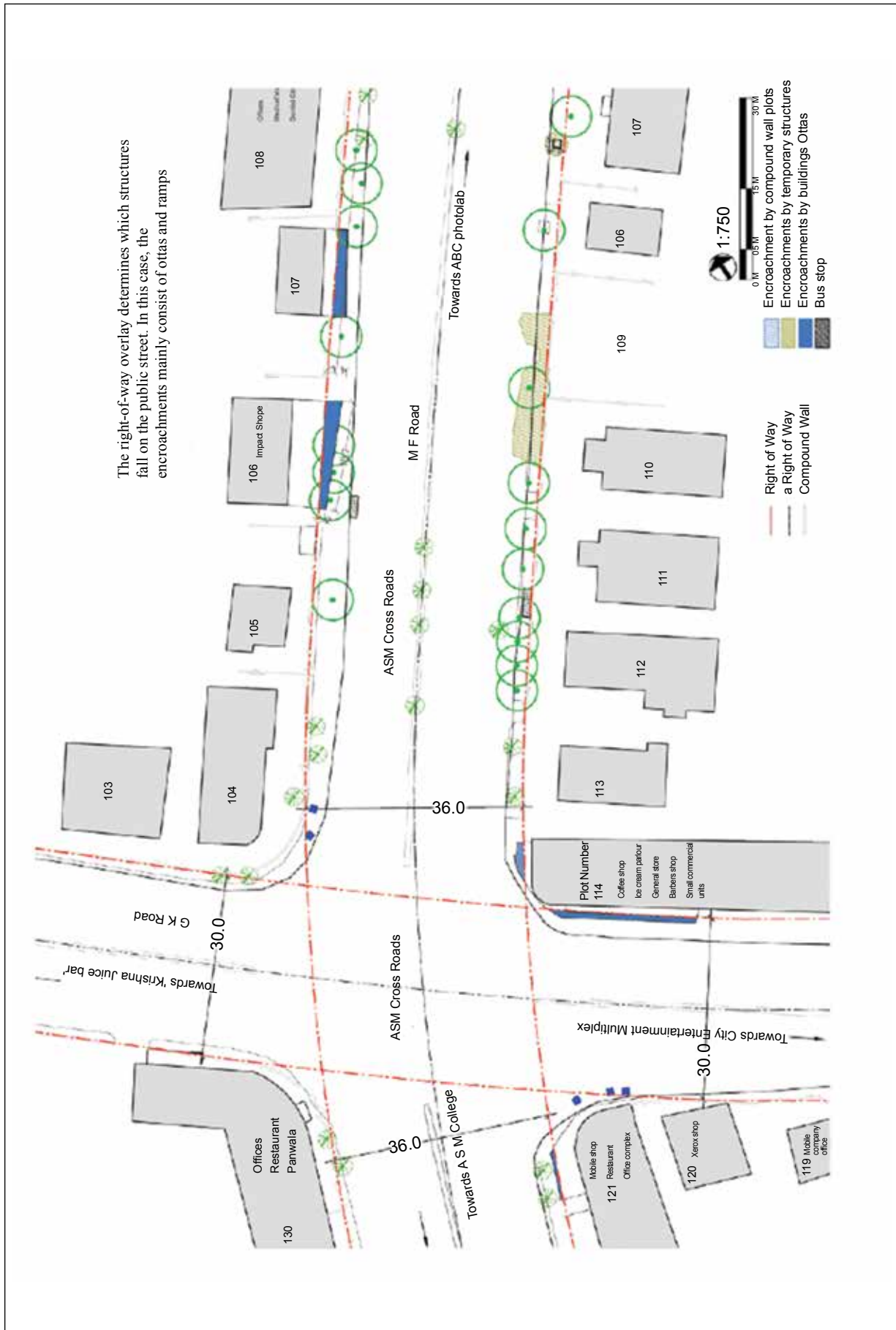


Fig. 25 Sample Line Drawing

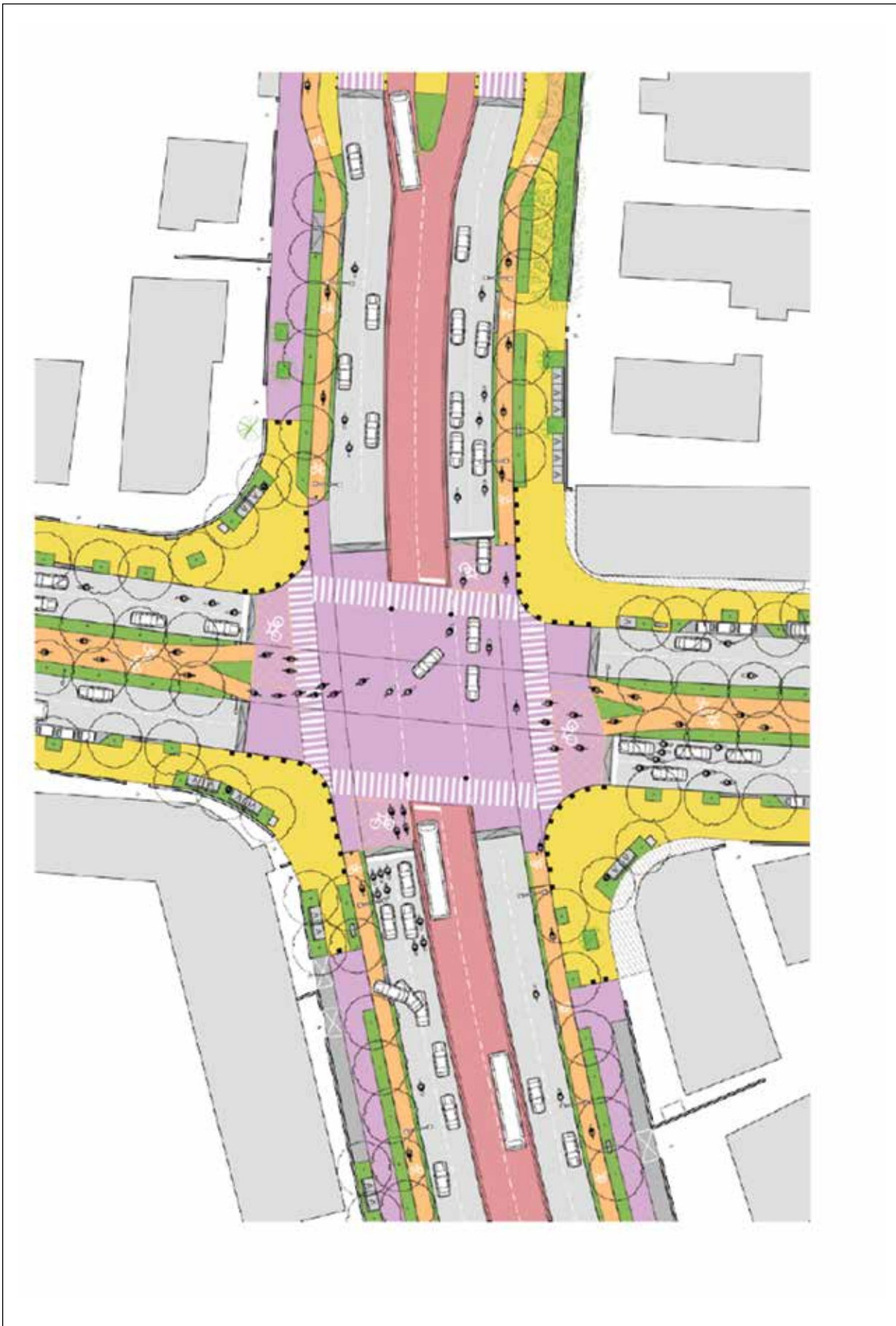


Fig. 26 Proposed Concept Plan with all Street Elements

5.4.3 *Community consultations*

Consultations in the form of public exhibitions or presentations must be organized to explain the salient features of the project, its benefits and obtain community feedback, during this stage. The suggestions should be evaluated and the necessary modifications may be made to the proposal.

5.4.4 *Coordination committee*

The proposed designs should be presented to the Coordination Committee and designs reviewed based on feedback from them.

5.4.5 *Test on site with temporary installations and markings*

Concept proposals should be marked on the road using chalk, traffic cones, and other temporary means and tested for functionality. In case any aspect of design is not compatible, the design should be modified as per site conditions. Detailed drawings should be prepared only after the Street Design Cell approves the concept plans.



Fig. 27 Testing of a Proposed Intersection Design in Coimbatore

5.4.6 *Construction drawings*

After the detailed designs are approved by the Street Design Cell, the construction drawings are prepared. These shall include:

- Street plan indicating
 - List of existing street elements to be demolished
 - Utility relocation plans, where necessary

- Installation/construction detail for each element

The Street Design Cell shall review, recommend modifications if any and approve the construction drawings. The Road Department would incorporate the suggested recommendations.

5.5 Tender Documents

This will include detailed drawings, construction drawings and bill of quantities along with the street implementation report. The tender documents shall be used for inviting bids from contractors.

5.6 Implementation Plan

A brief description of each aspect of implementation such as

- **Implementation Phasing:** This includes creating a phasing plan of implementing street design works keeping in view urgency of repairs, impact of the project and ensuring that traffic and pedestrian movement is least impacted.
- **Material Specifications:** This includes describing detailed material specifications for various components of the street.
- **Quality Assurance:** It includes creating a quality control guide for testing of relevant materials and workmanship on site as well as defining a standard code of practice for storage of material and for the construction process.
- **Work Zone Management Plan:** This includes creating a plan to ensure safe storage of material, cleaning and maintenance of the site as well as smooth movement of traffic and safe movement of pedestrians during the implementation process as also safety of workers.
- **Supervision:** This includes contract management and administration.

5.7 Maintenance

- Monitoring and maintenance clauses after implementation by the same contractor may be in-built into the contracts during implementation of road improvement/retrofitting projects. The defects liability period for the construction works may be aligned with the period of maintenance proposed.
- The implementing agency must conduct regular audits to effectively monitor the work done and get the required repairs and maintenance done on a regular basis.

5.8 Performance Monitoring

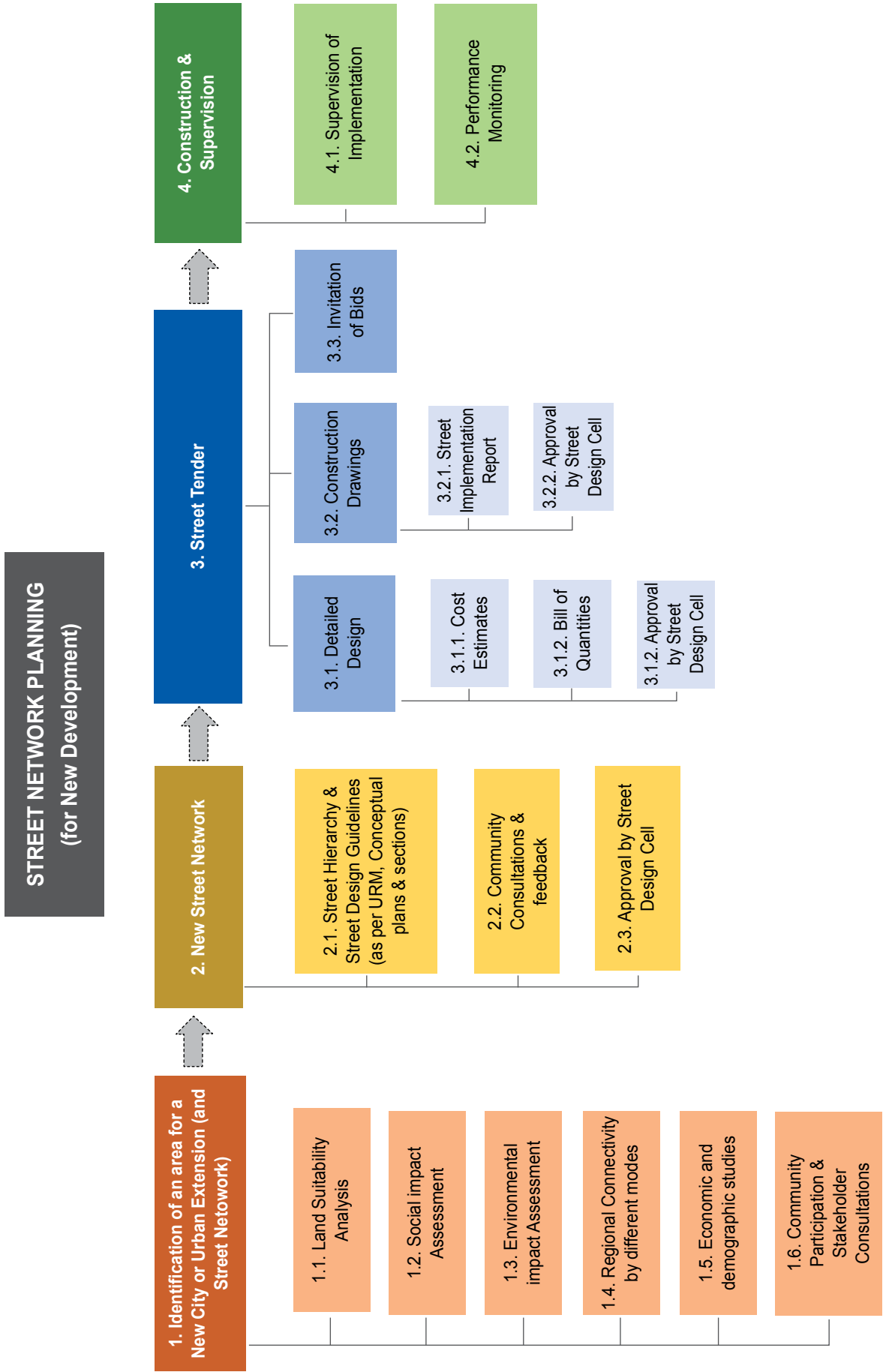
The city shall evaluate the impact of the project. As an example, following indicators could be adopted:

- Perception of safety, comfort and convenience of road users before and after the project. Road users shall cover pedestrians, cyclists, non-motorized transport and motorized vehicles both passengers and goods.
- Percentage increase in public transport and non-motorized transport facilities along the road stretch in compliance with “Persons with Disabilities Act, 1996”.
- Level of service on the stretch covered by the project based on the norms recommended by the Indian Highway Capacity Manual (Indo-HCM 2017).

SUGGESTED ROLES AND RESPONSIBILITIES OF THE STREET DESIGN CELL

- 1. Planning and Monitoring of Complete Streets**
 - Developing a comprehensive street design manual for the city, a street network plan and periodically revising both as needed.
 - Developing an implementation plan, clearly identifying new streets for implementation, developing implementation timeline, and identifying financing sources for street design projects.
 - Maintaining a database of topographic survey data, geo-technical information, and other databases required for detailed design and implementation.
 - Monitoring project implementation and maintaining a database of as-built drawings.
 - Developing, adopting and monitoring performance metrics to evaluate impact.
- 2. Detailed Designing and Implementation of Complete Streets**
 - Engaging with consultants to develop, and review detailed street designs.
 - Assist in selection of contractors for implementation and overseeing works at various stages.
 - Coordinating between contractors, consultants, and experts to address on-site issues during construction.
 - Conducting public stakeholder meetings as required.
 - Mediating any conflict between stakeholders (both public and governmental) during construction.
 - Monitoring physical infrastructure, to ensure that it is maintained over time and meets appropriate maintenance standards.
- 3. Capacity Building and Dissemination of Best Practices**
 - Convening conferences, workshops and seminars for awareness raising and dissemination of best practices in street design among city officials, consultants and others.
- 4. Community Engagement and Advocacy**
 - Communicating, building support for and communicating benefits of street design projects to the public through advocacy campaigns, media, and others.

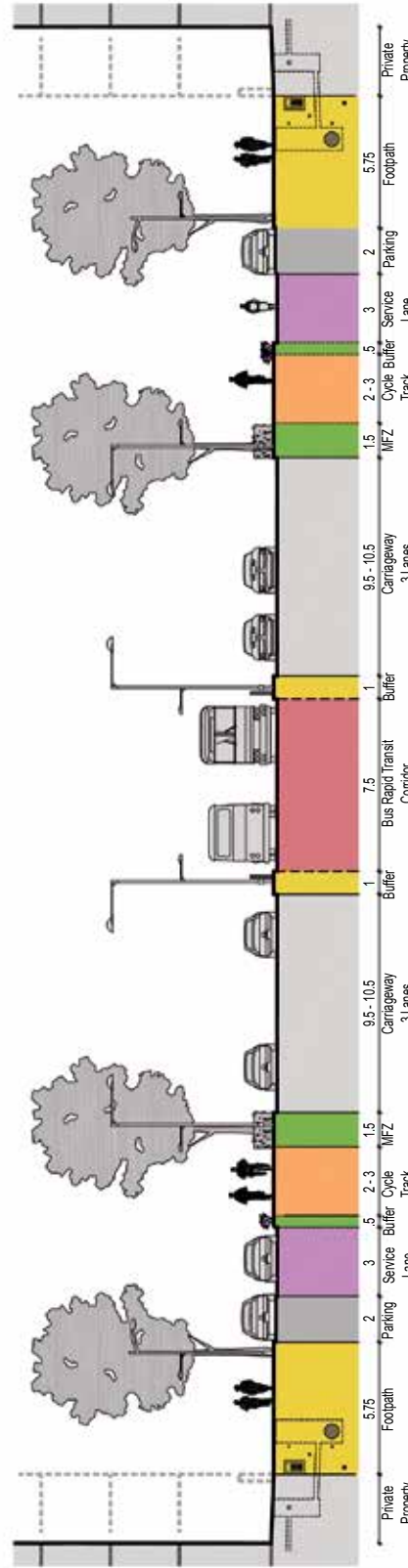
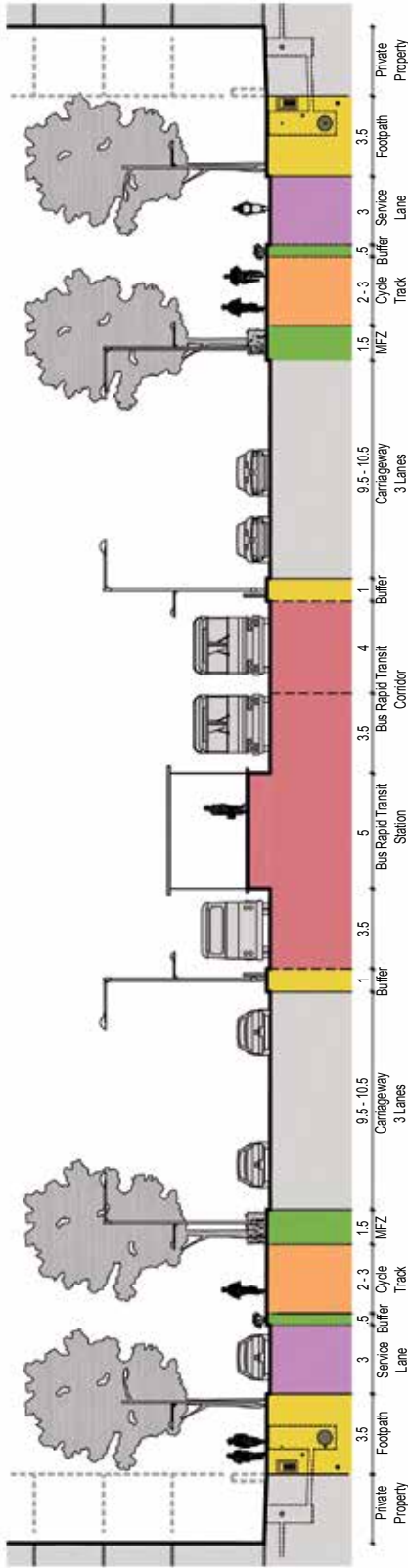
STREET DESIGN PROCESS FOR NEW ROADS



STREET DESIGN TEMPLATES

Typical cross sections and layouts for each class of urban roads are provided as guidelines for preparing detailed designs. The cross sections provided here depict equitable allocation of spaces for all modes of travel.

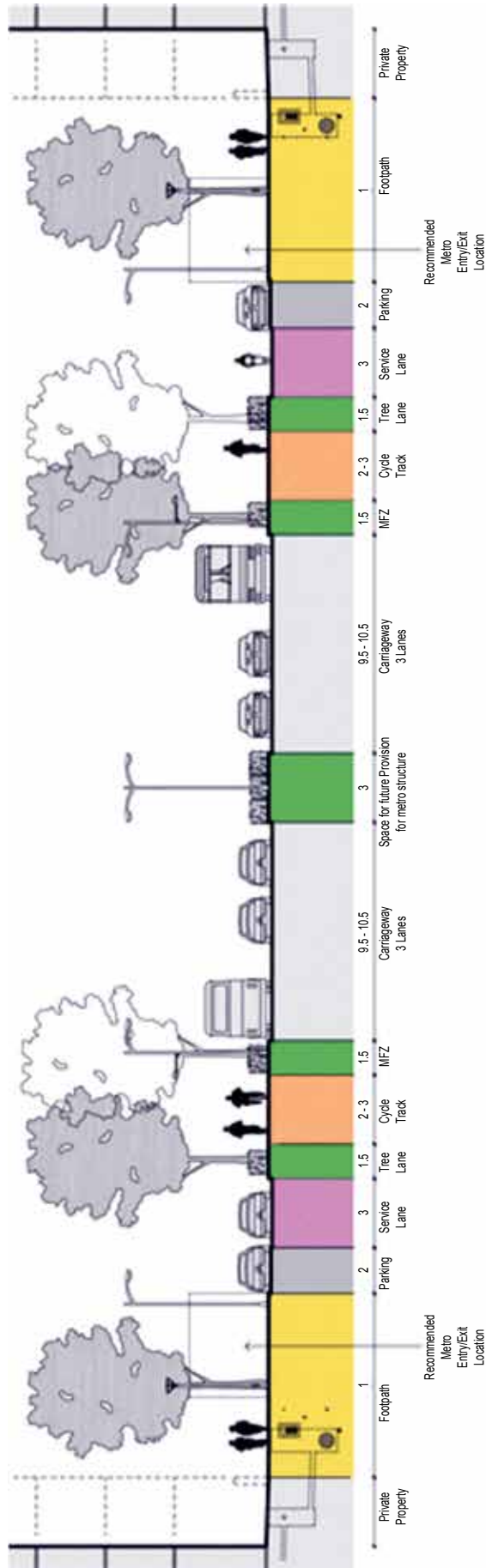
**Arterial Road
60A: 60 m right of way with bus rapid transit and service lane**



Pedestrian mobility and access	Footpath	Shared Space
Cyclist mobility	Median track	Side track
Parking and property access	Service lane	No Service lane
Private vehicle mobility	Divided carriageway	Undivided carriageway
		No carriageway

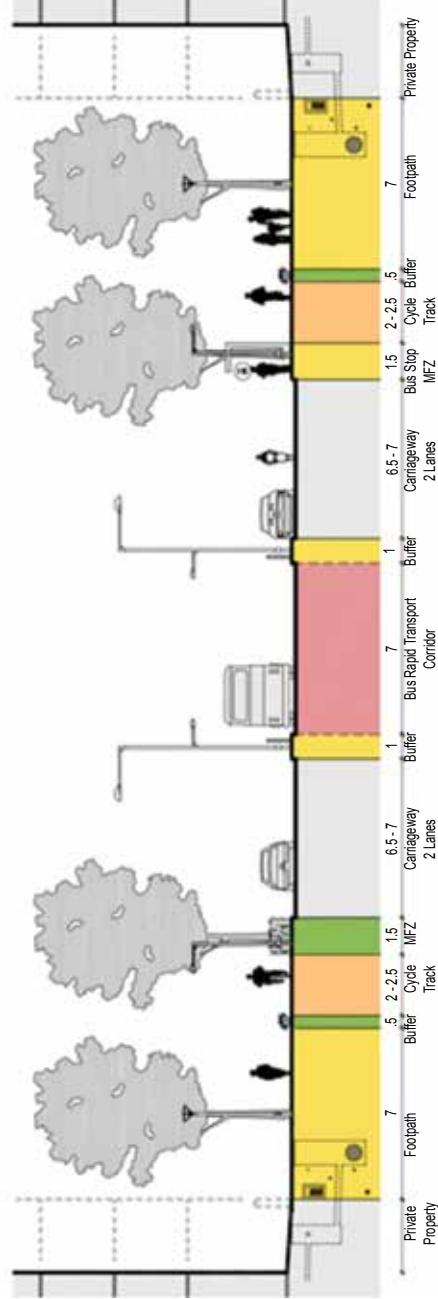
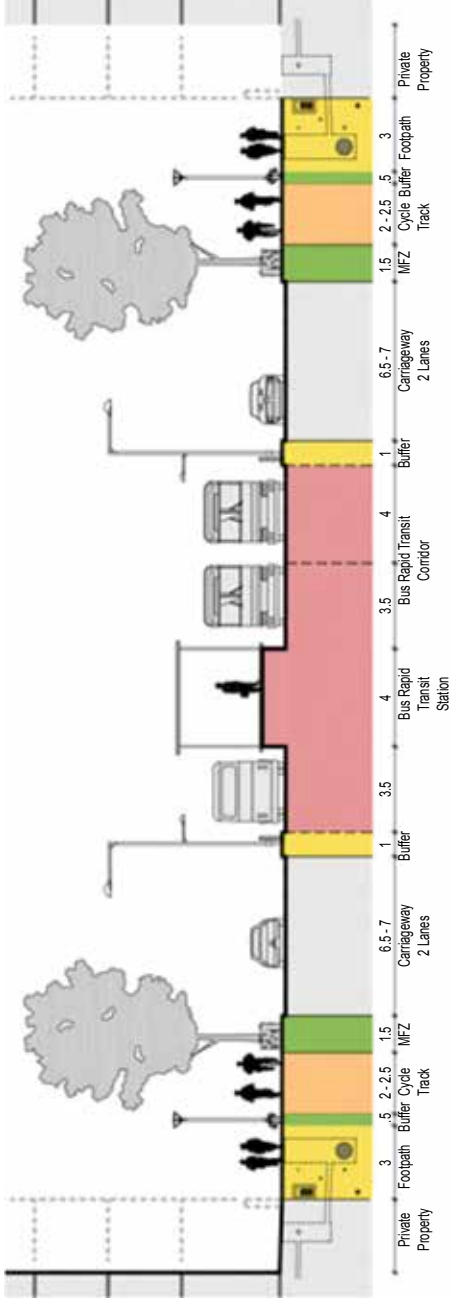
Arterial Road

60B: 60 m right of way with space provision for metro rail and service lane



Arterial Road

45A: 45 m right of way with bus rapid transit

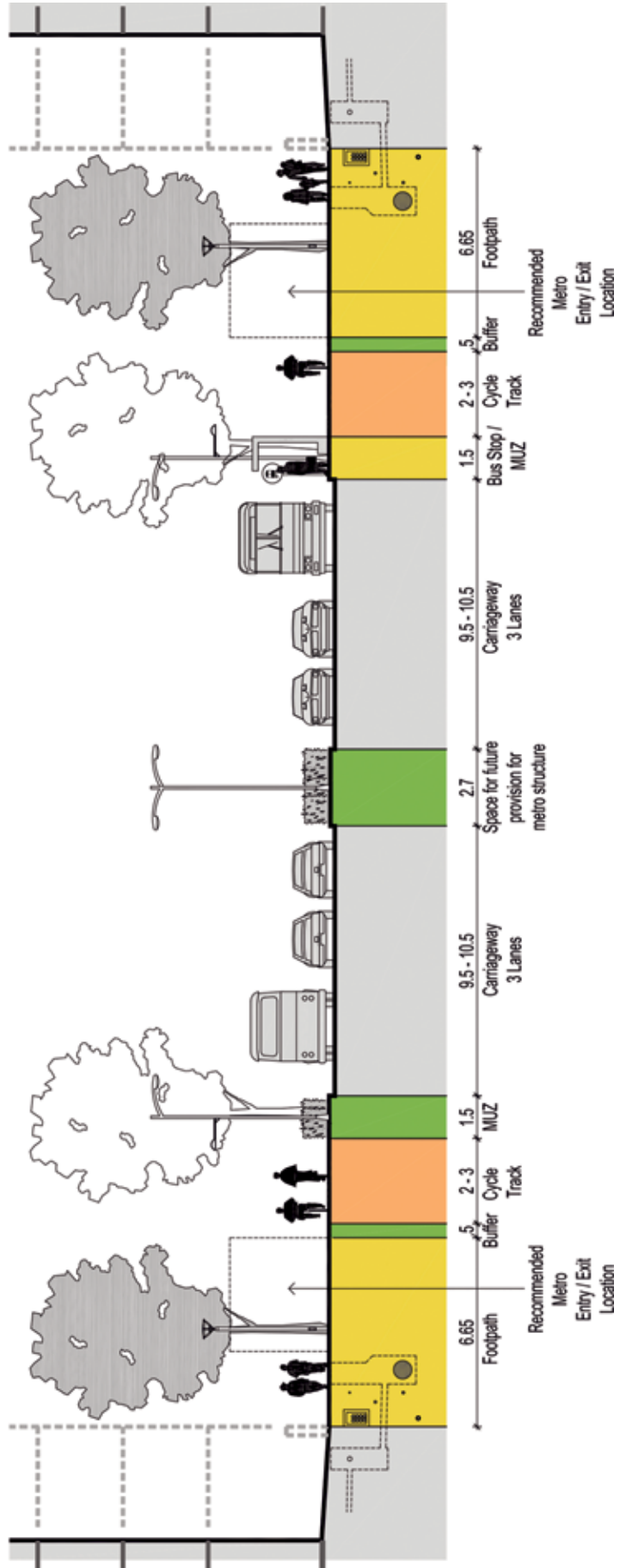


Footpath	Shared Space	Pedestrian mobility and access
Median track	Side track	Cyclist mobility
Service lane	No Service lane	Parking and property access
Divided carriageway	Undivided carriageway	Private vehicle mobility

Arterial Road

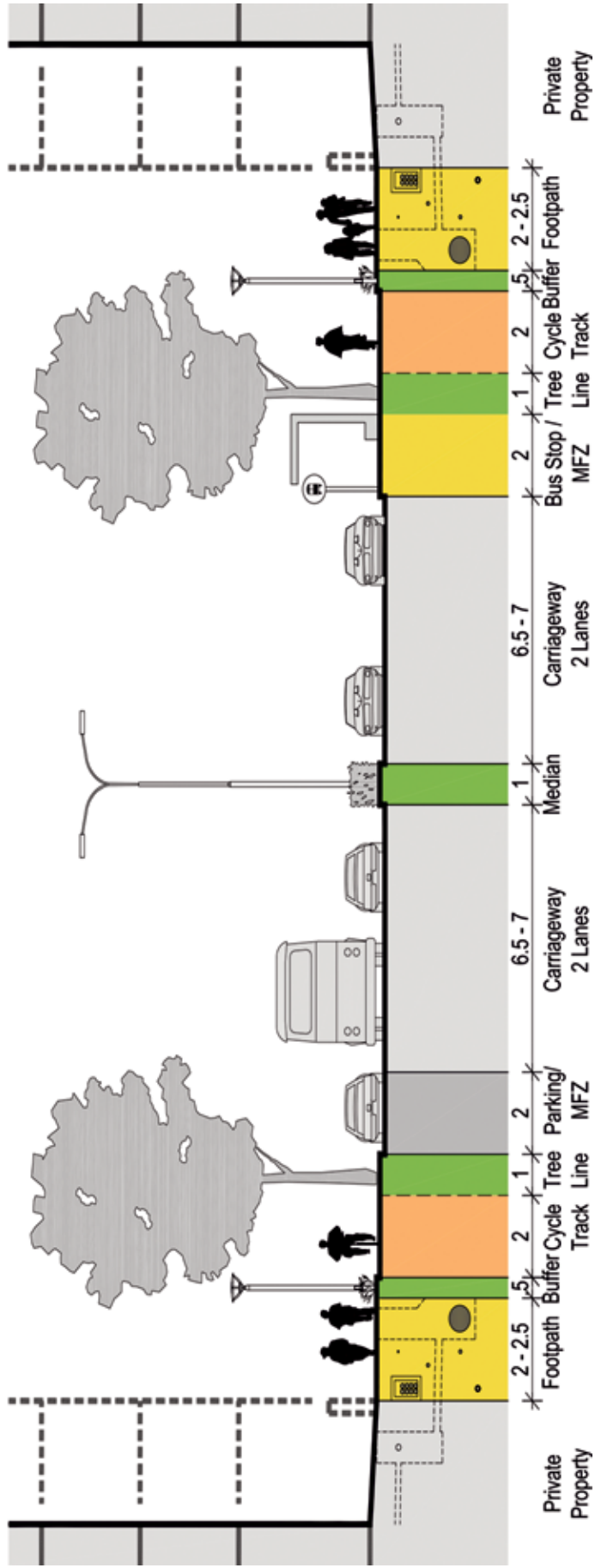
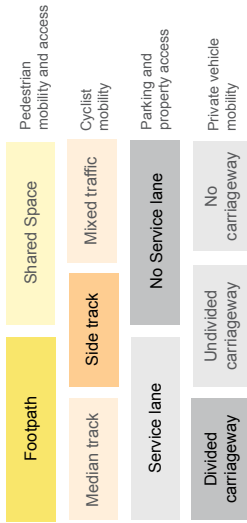
45B: 45 m right of way with space provision for metro rail

Footpath	Shared Space	Pedestrian mobility and access
Median track	Side track	Cyclist mobility
Service lane	No Service lane	Parking and property access
Divided carriageway	Undivided carriageway	Private vehicle mobility
	No carriageway	



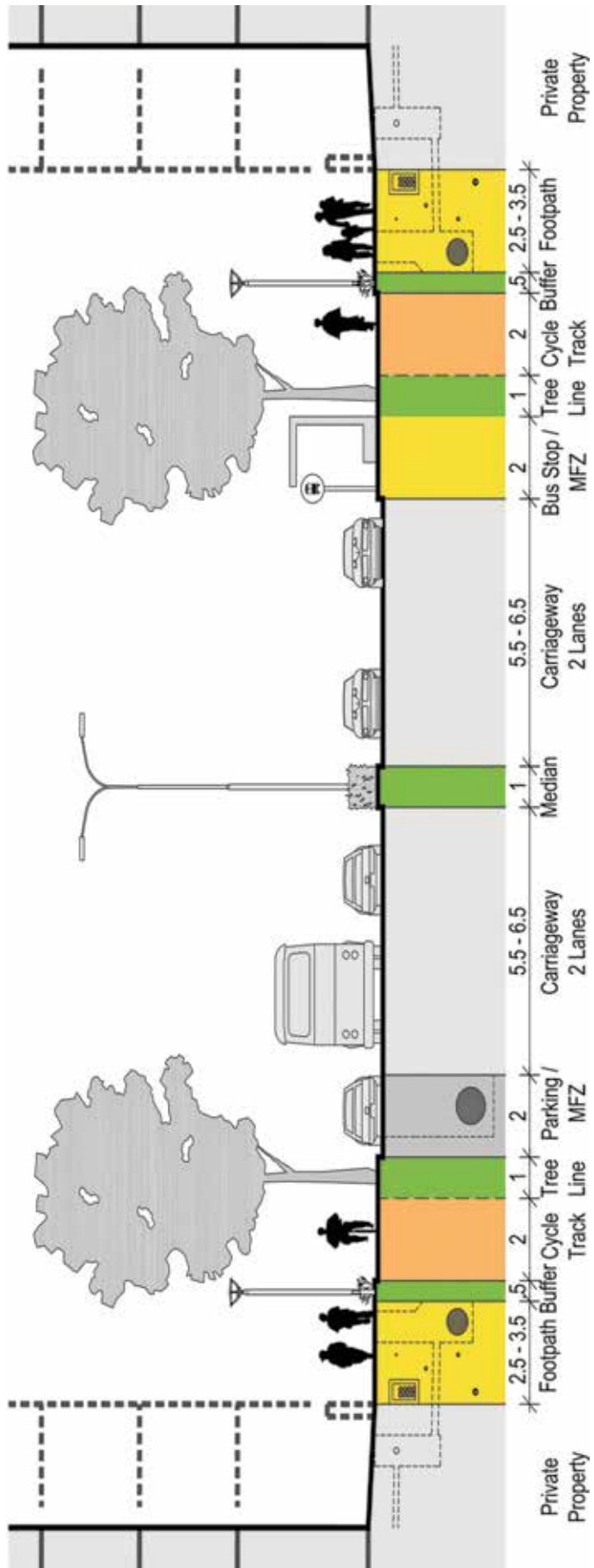
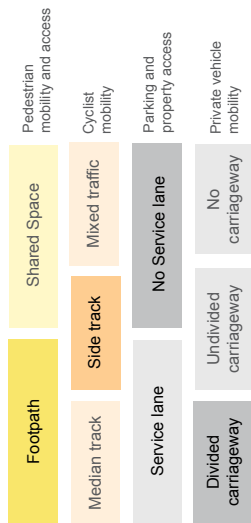
Sub-Arterial Road

30A: 30 m right of way with side cycle tracks



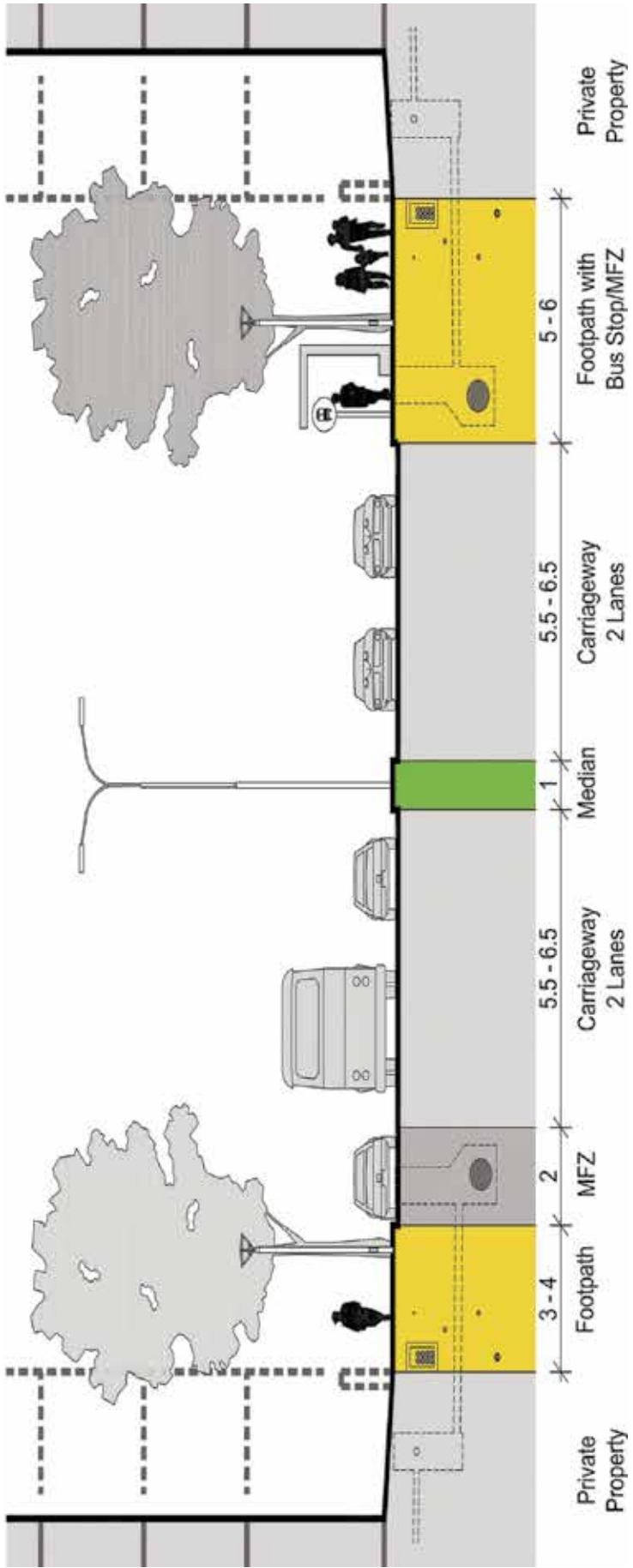
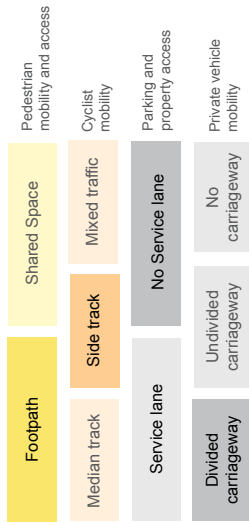
Collector Street

30A: 30 m right of way with side cycle tracks



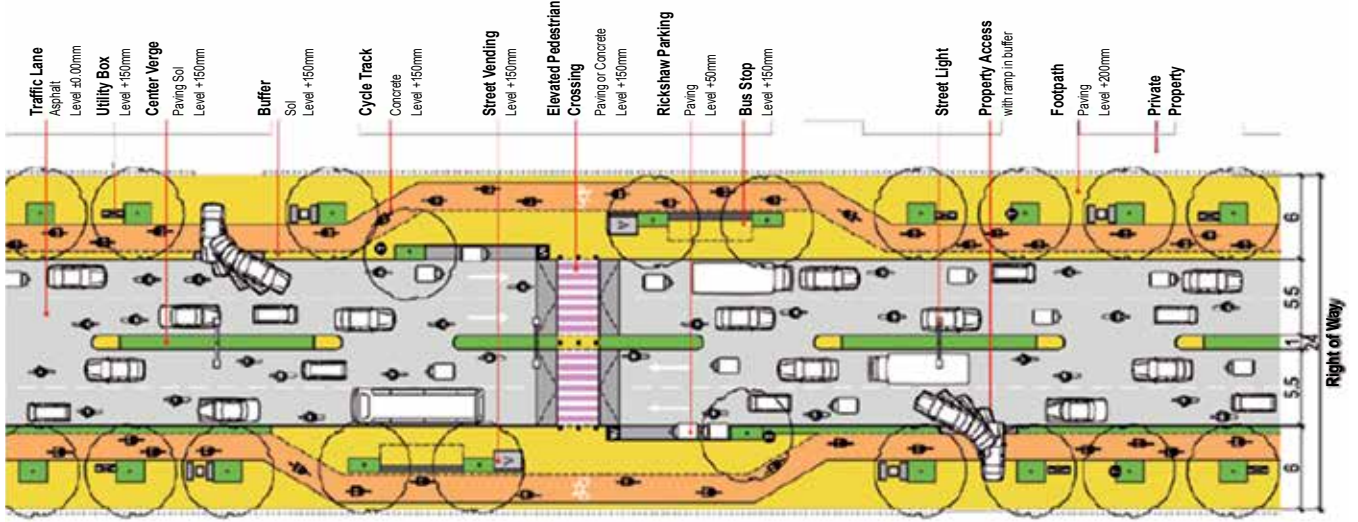
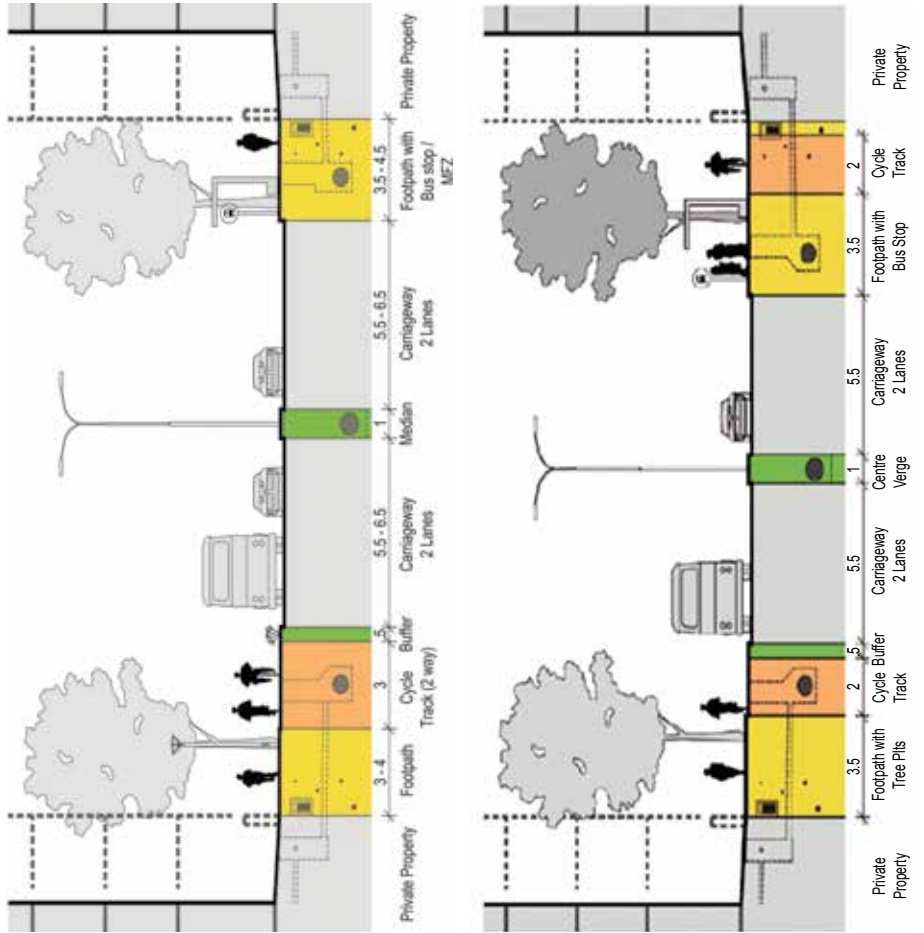
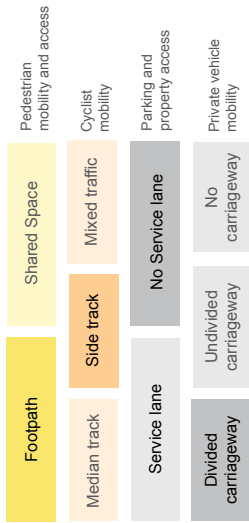
Collector Street

24A: 24 m right of way without cycle tracks



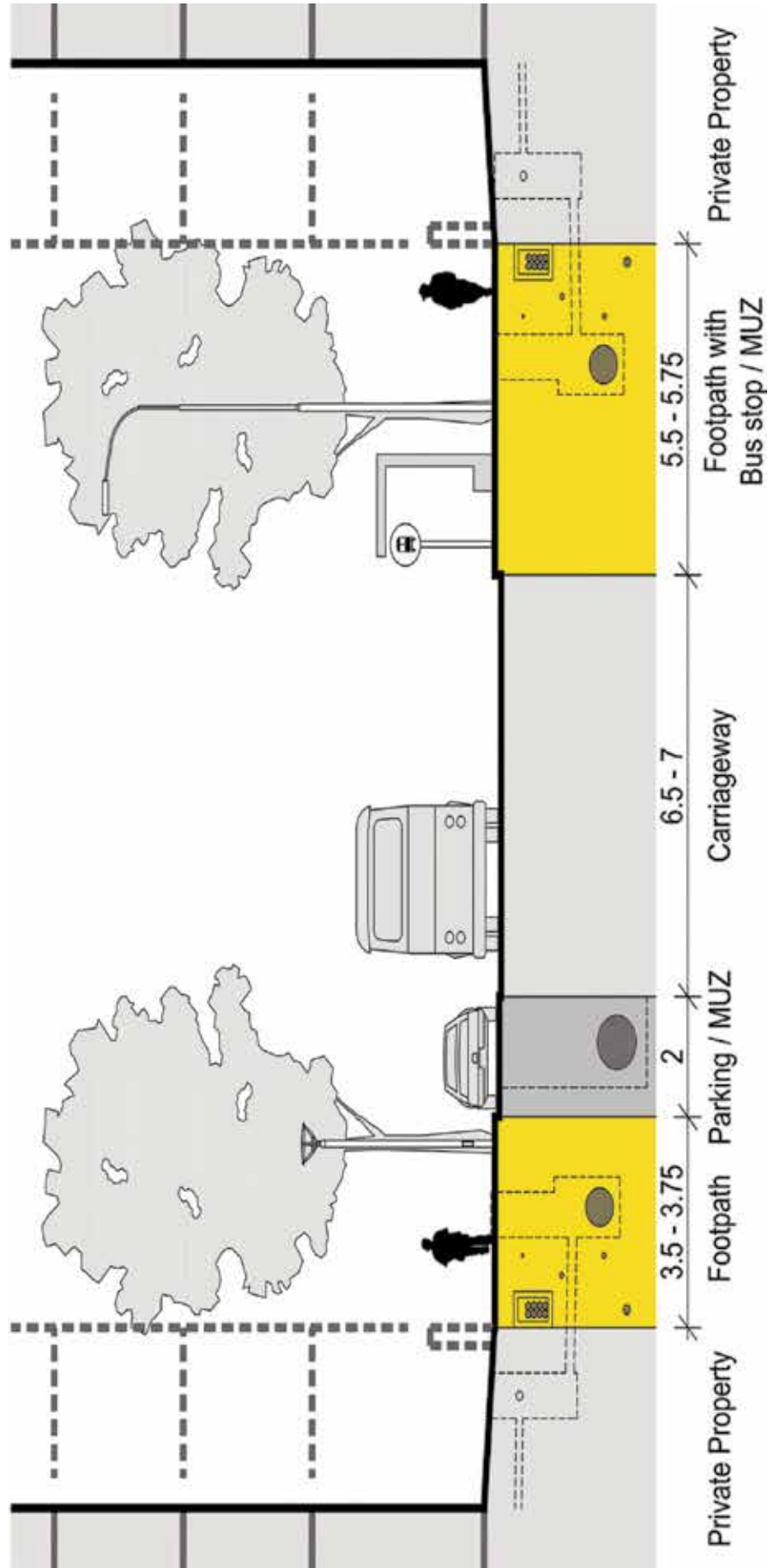
Collector Street

24B: 24 m right of way with side cycle tracks or combined



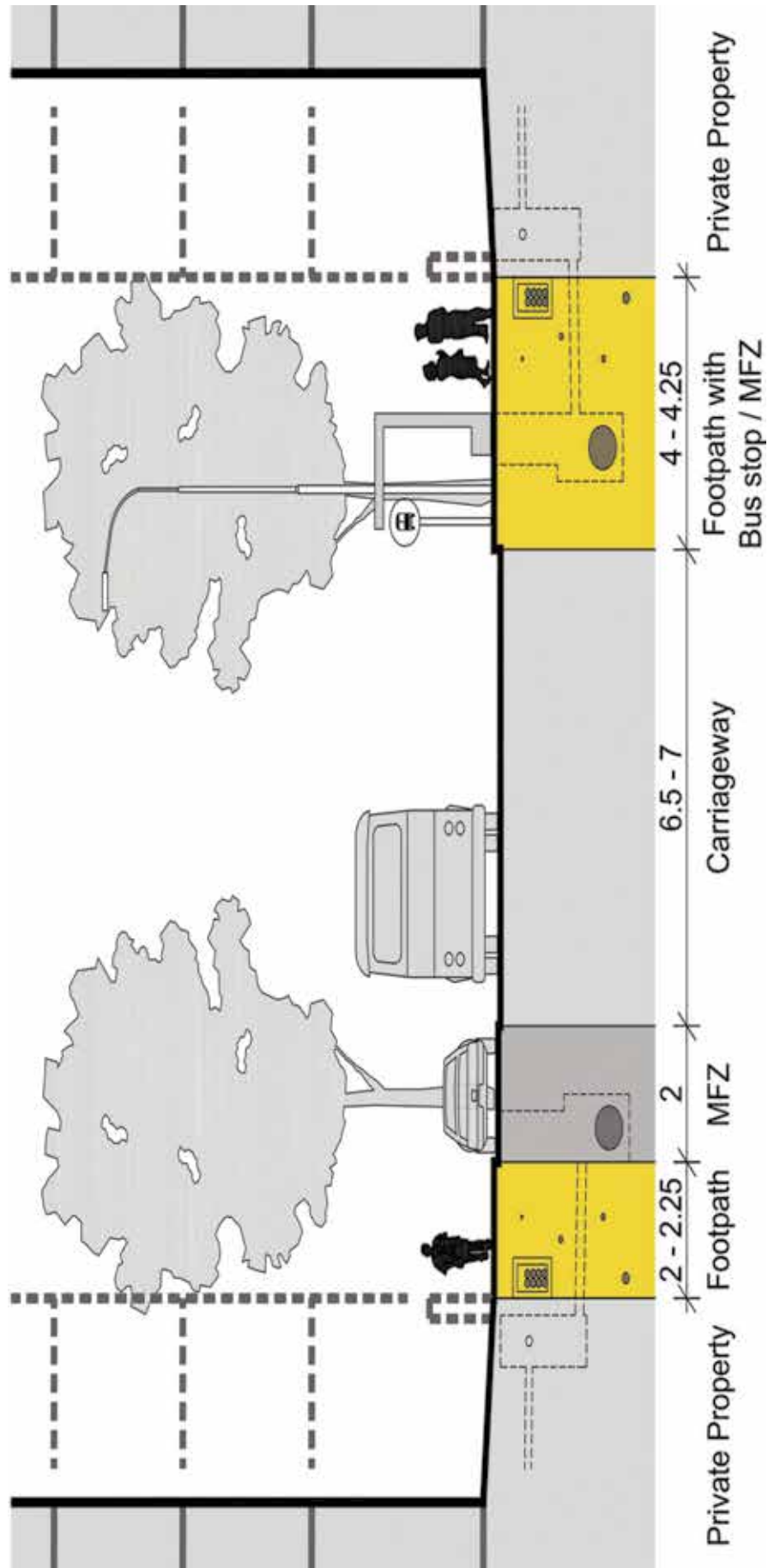
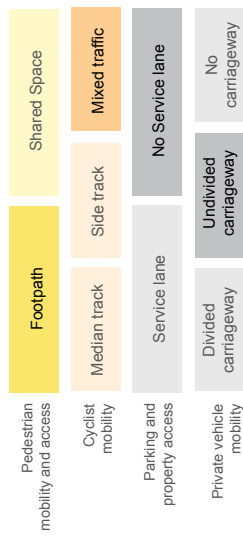
Collector Street

18A: 18 m right of way with footpaths on both sides



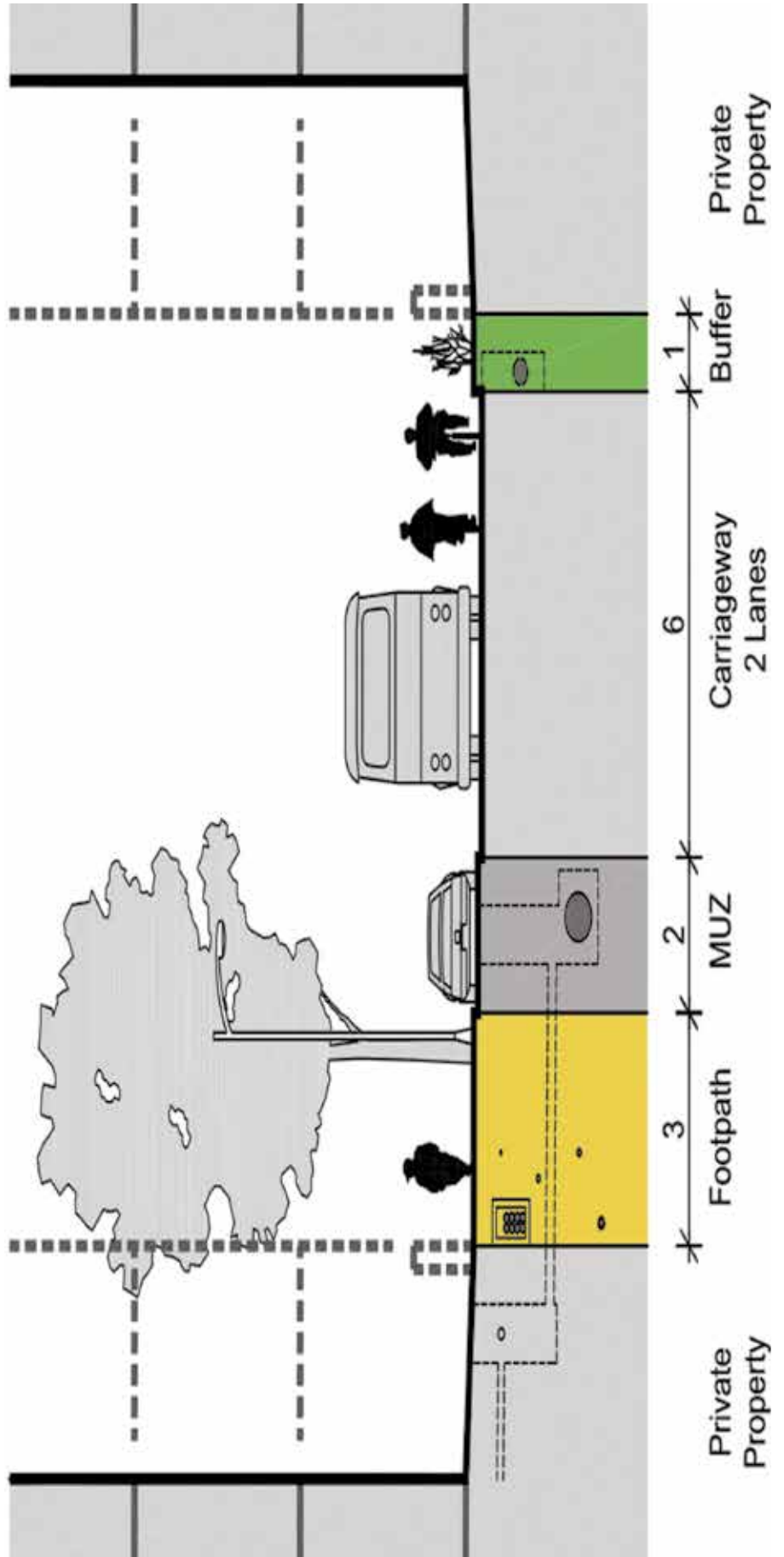
Collector Street

15A: 15 m right of way with footpaths on both sides



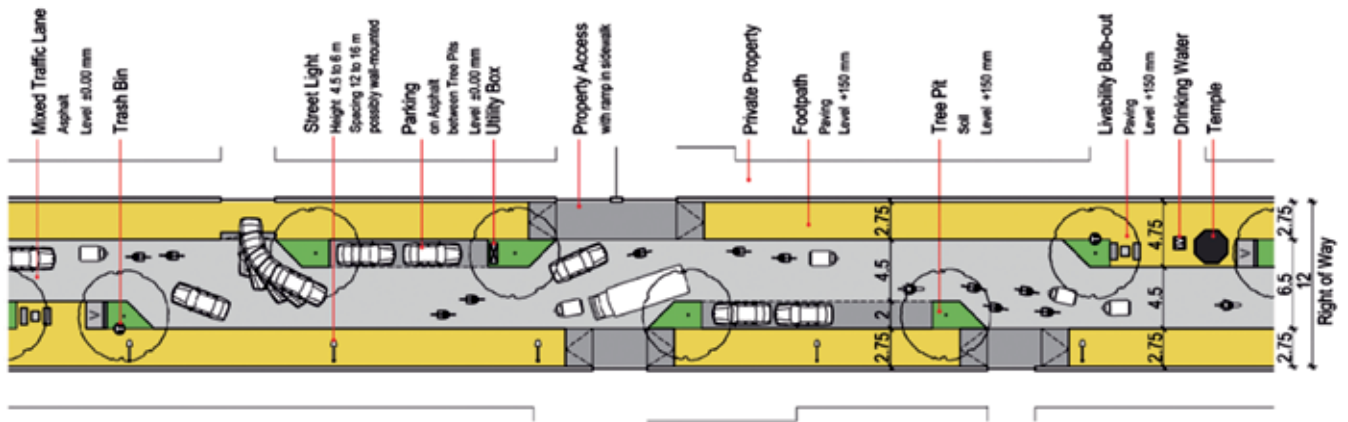
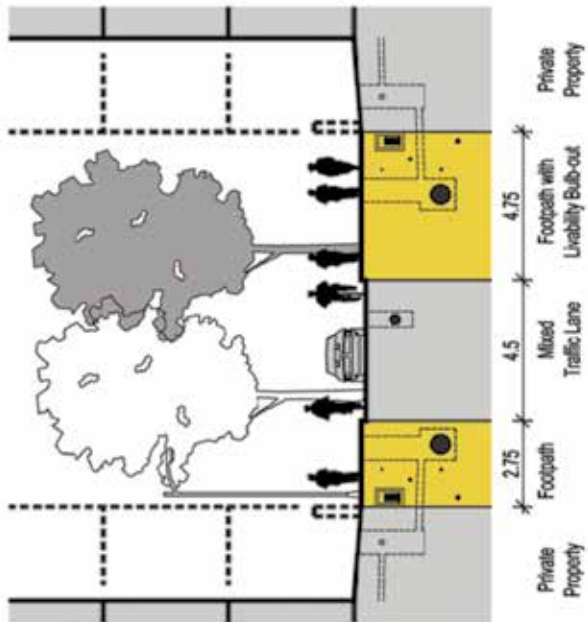
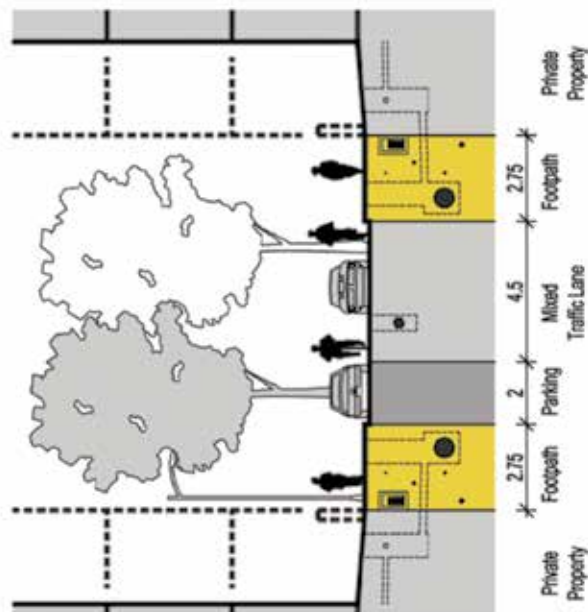
Local Street

12A: 12 m right of way with footpaths on both sides



Local Street

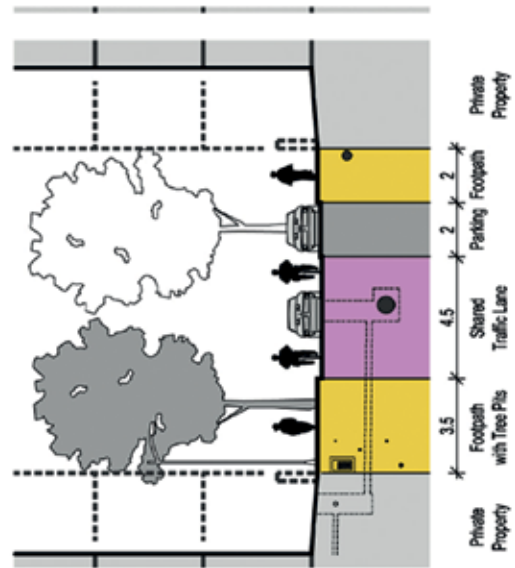
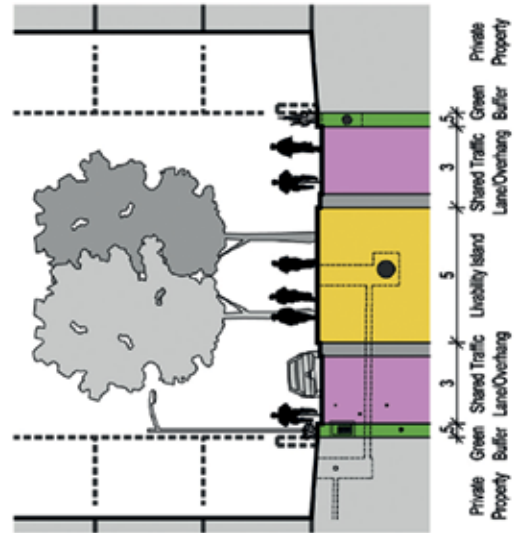
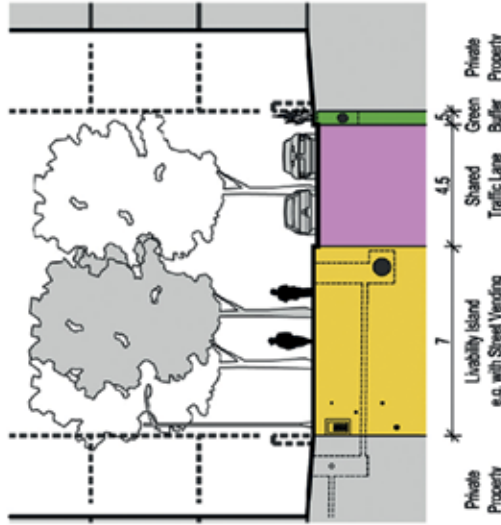
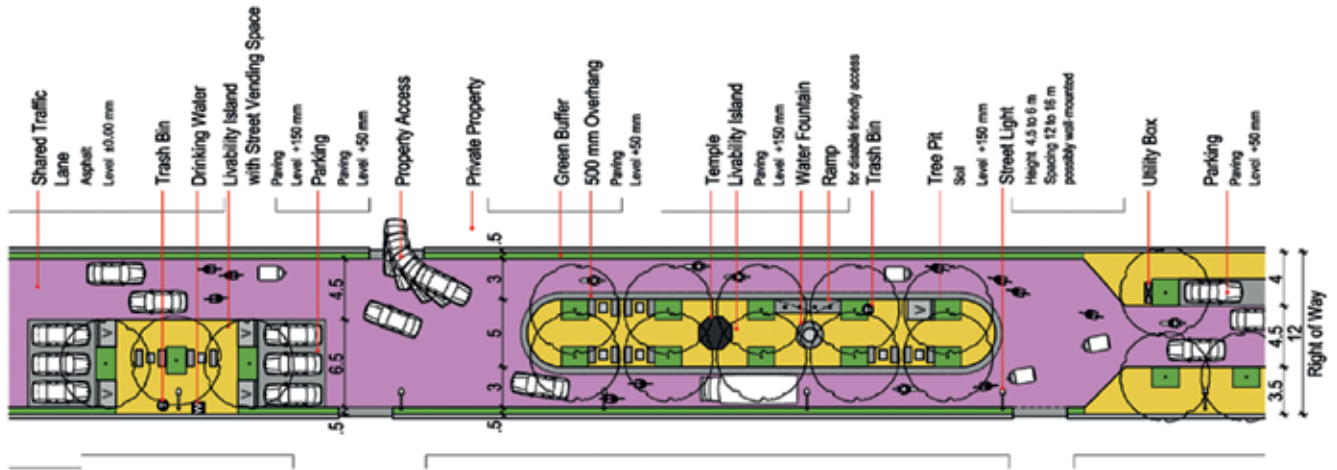
12B: 12 m right of way with footpaths on both sides



Local Street

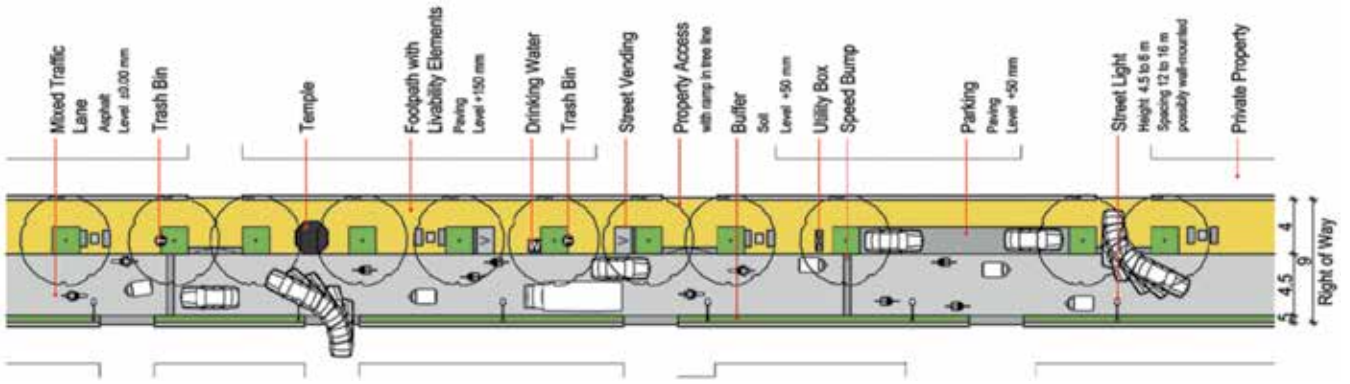
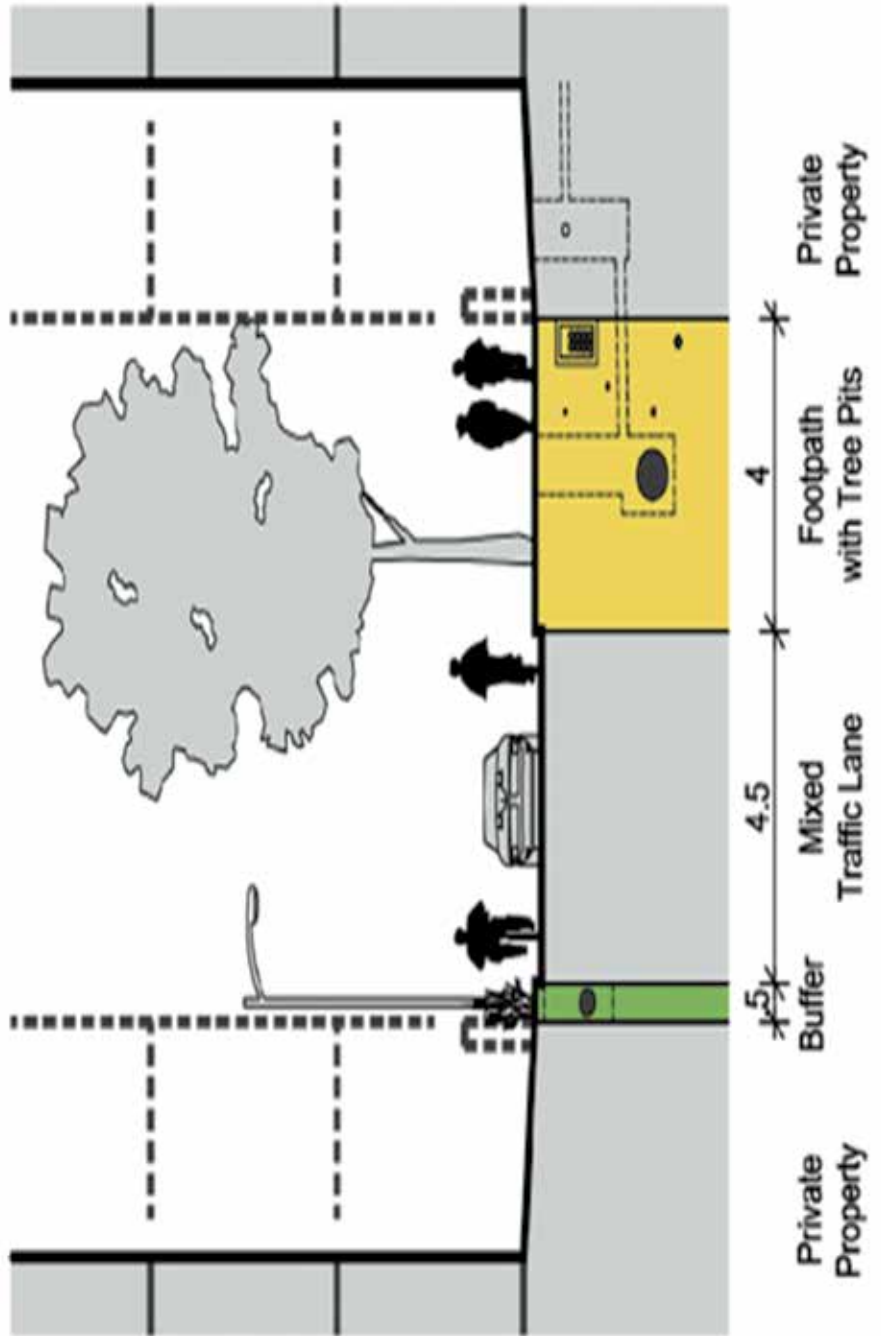
12C: 12 m right of way shared street

Small Streets with shared space



Local Street

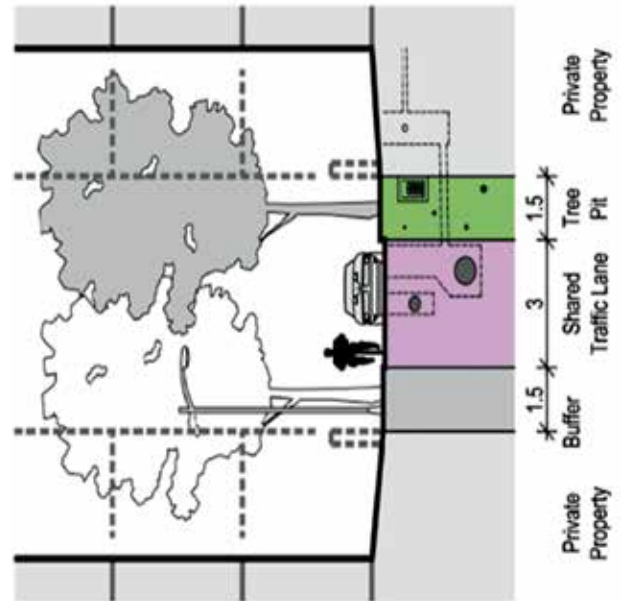
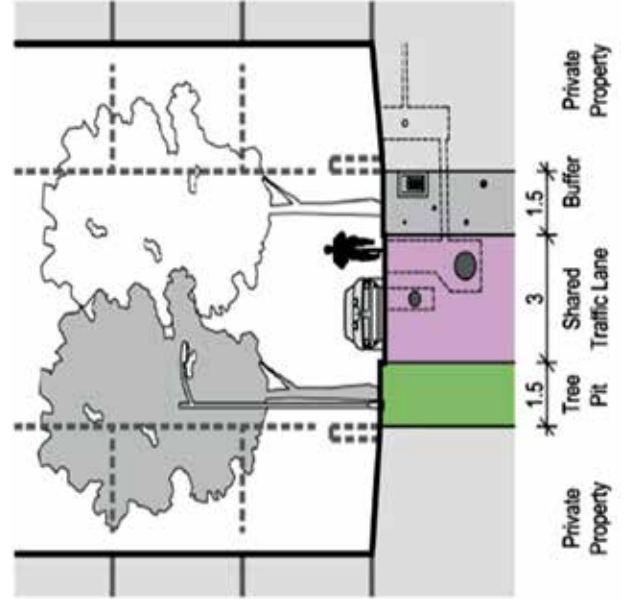
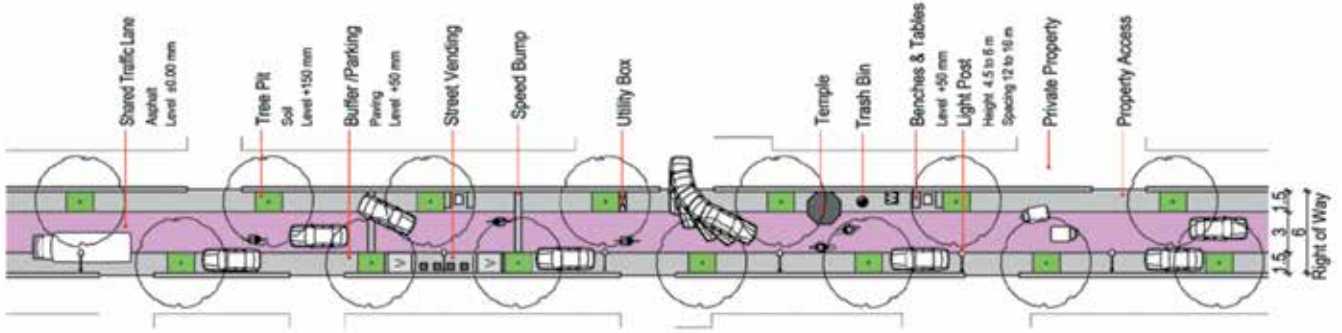
9A: 9 m right of way with footpath on one side



Local Street

6A: 6 m right of way, shared street

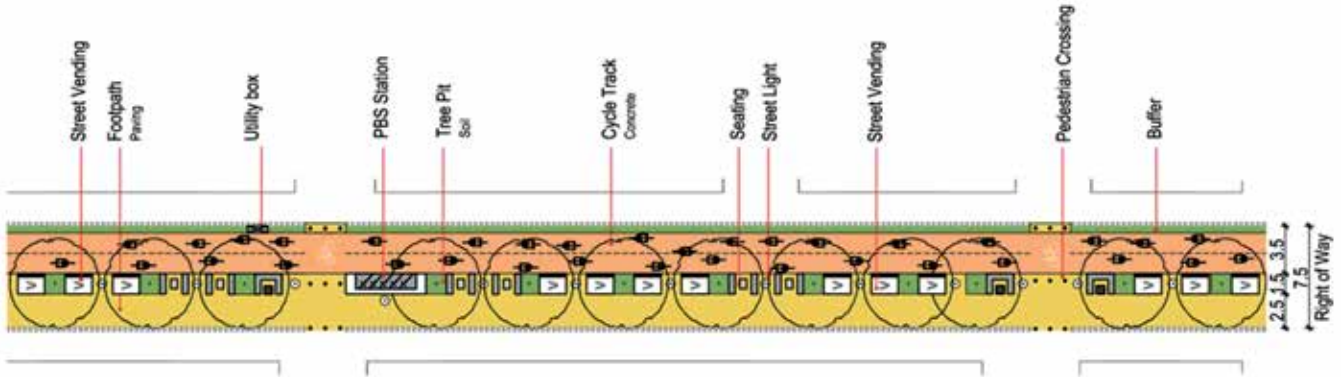
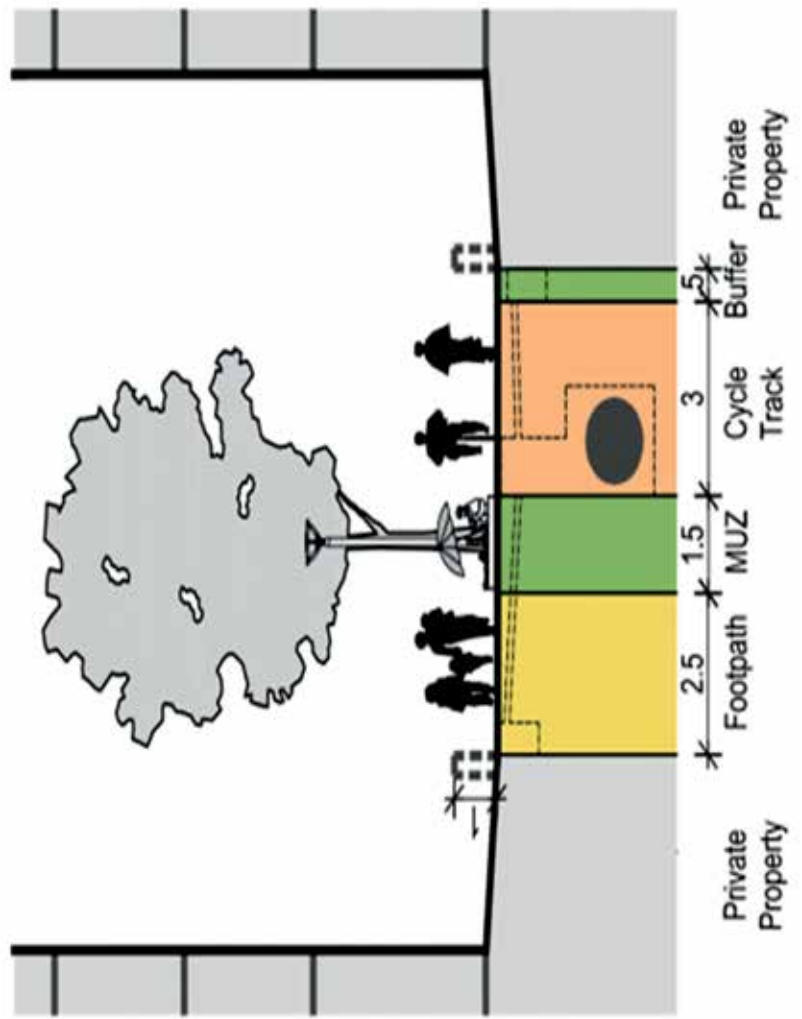
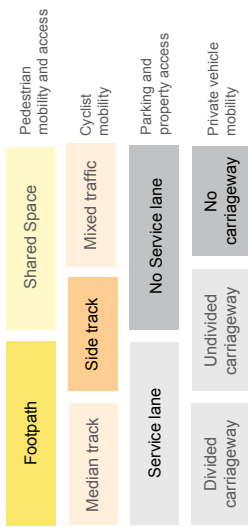
Pedestrian mobility and access	Footpath	Shared Space
Cyclist mobility	Median track	Side track
Parking and property access	Service lane	No Service lane
Private vehicle mobility	Divided carriageway	Undivided carriageway
		No carriageway



Non-Motorized Transport (NMT) Pathway

7.5A: 7.5 m Greenway

Greenways

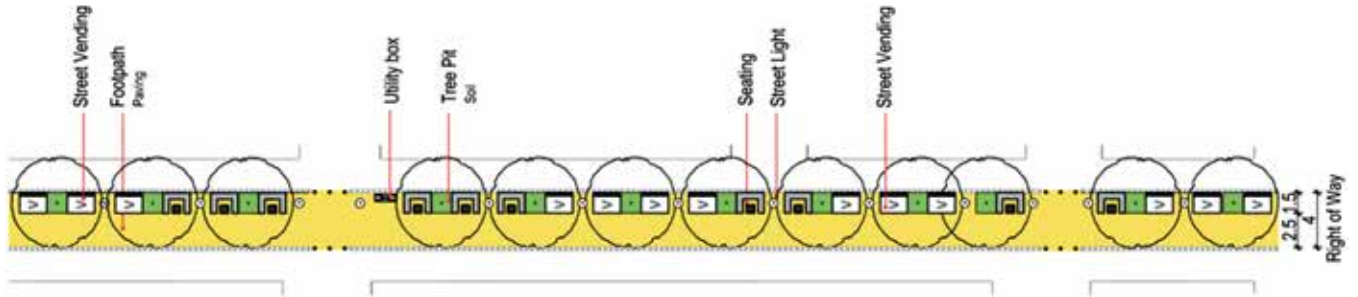
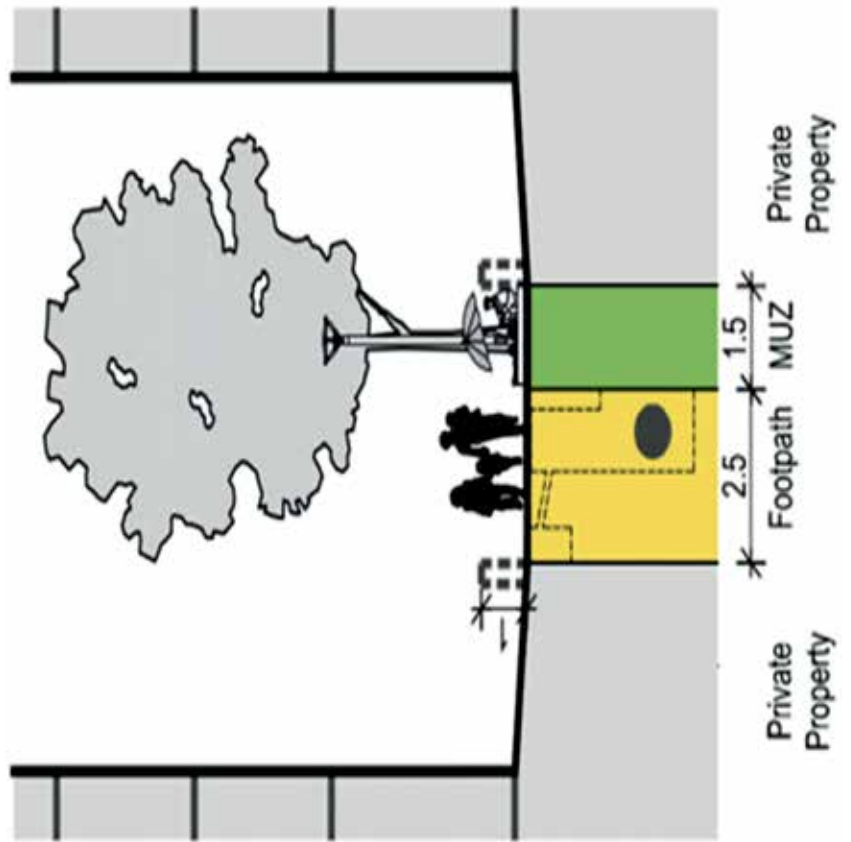


Non-Motorized Transport (NMT) Street

4A: 4 m Pedestrian Path

Pedestrian Paths

Footpath	Shared Space	Pedestrian mobility and access
Median track	Side track	Cyclist mobility
Service lane	No Service lane	Parking and property access
Divided carriageway	Undivided carriageway	Private vehicle mobility
	No carriageway	



REFERENCES

1. Access Management on Arterial Roads Report - Lehigh Valley www.lvpc.org/pdf/accessMgmOnArterialRoads.pdf
2. Institute for Transportation and Development Policy (ITDP), Better Streets Better Cities <https://www.itdp.org/wp-content/uploads/2011/12/Better-Streets-Better-Cities-ITDP-2011.pdf>
3. Clarke A., Traffic Calming, Auto-Restricted Zones and Other Traffic Management Technique: Their Effects on Bicycling and Pedestrians, National Bicycling and Walking Stud, #19, FHWA (Washington DC; www.bikefed.org), 1994, in Litman T., Benefits and Costs, Evaluating Traffic Calming Benefits, Cost and Equity Impacts, Victoria Transport Policy Institute, 1997-99
4. Bus Rapid Transit System (BRTS) Evaluation and Design (BEAD) tool <http://shaktifoundation.in/report/bead-toolkit-project-report/>
5. Design Manual for Urban Roads and Streets - Environ www.environ.ie/sites/default/files/migrated-files/en/.../FileDownload,32669,en.pdf
6. Harmonized Guidelines and Space Standards for Barrier Free Built Environment for Persons with Disability and Elderly Persons; February 2016, by Ministry of Urban Development.
7. Integrated Land Use and Transport Planning - Urban Transport Group www.urbantransportgroup.org/.../20112706ptegThrivingCitiesReportforWebFINAL
8. Unified Traffic and Transportation Infrastructure (Planning and Engineering) Center (UTTIPEC), Street Design Guidelines www.uttipeec.nic.in/StreetGuidelines-R1-Feb2011-UTTPEC-DDA.pdf
9. <https://mail.google.com/mail/u/0/#search/DDA+gazette+notification+on+transportation+chapter/14fd9ffea1e6a9d3>
10. Effects of Site Design on Pedestrian Travel in Mixed-Use, Medium-Density Environments by A Moudon et al. Washington State Transportation Center (TRAC).
11. EMBARQ Report, Safe Access Manual
12. Development of Toolkit under “Sustainable Urban Transport Project”; Land Use Transport Integration and Density of Urban Growth”, by IUT, SUTP and CEPT for Ministry of Urban Development.
13. UMTA of Different States in India http://www.cppr.in/wp-content/uploads/2013/11/Sonakshi_Report.pdf
14. National Mission for Sustainable Habitat- Policies and Strategies by MoUD
15. Institute for Transportation and Development Policy (ITDP) National Urban Transport Policy 2014
16. Ministry of Urban Development (MoUD), Draft Generic Operations Document for Unified Metropolitan Transport Authority
17. A Policy on Geometric Design of Highways and Streets 2001, AASHTO
18. NACTO Urban Street Design Guide <http://nacto.org/publication/urban-street-design-guide/interim-design-strategies/moving-the-curb/>
19. Universal Accessibility Guidelines for Pedestrian, Non-Motorized Vehicle and Public Transport Infrastructure, Samarthyam & SHAKTI

20. Parameters for the National Mission on Sustainable Habitat (NMSH) – Report of the Sub-Committee on Urban Transport
21. IRC:46 "A Policy on Roadside Advertisements"
22. IRC:69 "Space Standards for Roads in Urban Areas"
23. IRC:70 "Regulation and Control of Mixed Traffic in Urban Areas"
24. IRC:86 "Geometric Design Standards for Urban Roads and Streets"
25. IRC:92 "Guidelines for the Design of Interchanges in Urban Areas"
26. IRC:93 "Guidelines on Design and Installation of Road Traffic Signals"
27. IRC:99 "Guidelines for Traffic Calming Measures in Urban and Rural Areas"
28. IRC:102 "Traffic Studies for Planning Bypasses around Towns"
29. IRC:106 "Guidelines for Capacity of Urban Roads in Plain Areas"
30. IRC:103 "Guidelines for Pedestrian Facilities"
31. IRC:SP:43 "Guidelines on Low-Cost Traffic Management Technique for Urban Areas"
32. Sustainable Urban Transport Principles and Implementation Guidelines for Indian Cities
<http://shaktifoundation.in/report/sustainable-urban-transport-principles-and-implementation-guidelines-for-indian-cities/>
33. Urban and Regional Development Plans Formulation and Implementation (URDPFI) Guidelines (Vol-I), Ministry of Urban Development, 2015.
34. Jennifer Dill (2004) "Measuring Network Connectivity for Bicycling and Walking" Doctoral Thesis, School of Urban Studies and Planning, Portland State University, Portland, OR USA; jdill@pdx.edu
35. Unified Traffic and Transportation Infrastructure (Planning and Engineering) Center (UTTIPEC) (2012) Public Notice for DRAFT TOD Policy; <http://uttipec.nic.in/writereaddata/mainlinkFile/File392.pdf>
36. Unified Traffic and Transportation Infrastructure (Planning and Engineering) Center (UTTIPEC) and DIMTS; Technical Report on Optimization of Transport Networks in Proposed Transit Oriented Development Zones, 2012.
37. Mountainland, Wasatch Front Regional Council, Utah Transit Authority (UTA), and Utah Department of Transportation (UDOT), The Utah Street Connectivity Guide; <https://www.mountainland.org/utah-street-connectivity-guide>, 2017
38. Ahmedabad Development Plan and CBD LAP 140827, ITDP; 2014
39. <http://www.activehealthycommunities.com.au/plan/gis-analysis/walking-cycling-pedshed-analysis/>
40. <http://pedshed.net/>
41. <http://www.jacobdibble.com/?p=786>
42. <http://www.mfe.govt.nz/publications/towns-and-cities/urban-design-toolkit-third-edition/section-1-research-and-analysis>
43. <https://www.cnu.org/our-projects/street-networks/street-networks-101>
44. Indian Highway Capacity Manual (Indo-HCM 2017), CSIR-Central Road Research Institute, New Delhi
45. World Report on Disability (2011), World Health Organization

(The Official amendments to this document would be published by the IRC in its periodical, 'Indian Highways' which shall be considered as effective and as part of the Code/Guidelines/Manual, etc. from the date specified therein)