Street Design Guidelines

"...for Equitable Distribution of Road Space" - NUTP

Nov 2010

The Governing Body of Unified Traffic and Transportation Infrastructure (Plg. & Engg.) Centre (UTTIPEC) under the Chairmanship of Sh. Tejendra Khanna, Hon'ble Lt. Governor had earlier approved the "Pedestrian Design Guidelines" on 20.11.09 as per the recommendation of the Working Group for immediate implementation, enforcement and uniform adoption by all the road owning agencies.

After 6 months a review of the Pedestrian Design Guidelines was initiated and discussed in the Working Group - I A meetings held on 23.6.10, 23.7.10, 17.8.10 and 19.11.10. It was suggested that "Pedestrian Design Guidelines" to be renamed as "Street Design Guidelines" after incorporating the suggestions of the Working Group.

The Governing Body approved the final revised "Street Design Guidelines" in its 27th meeting held on 25.11.10 under the Chairmanship of Sh. Tejendra Khanna, Hon'ble Lt. Governor, as per the recommendation of the Working Group - I A meeting dated 19.11.10.

Acknowledgements

The preparation of Draft Pedestrian Design Guidelines was initiated after a detailed presentation on "Great Pavements for Delhi" was made by Ms. Paromita Roy, Sr. Consultant, UTTIPEC in the Governing Body meeting on 24.4.2009. The presentation was appreciated and road owning agencies were requested to adopt some of the best practices on pilot project basis. As a follow up, these set of guidelines were put together, based on best practices available around the world and customized to ground conditions and challenges in India, particularly in Delhi. In this, the UTTIPEC Core team was helped immensely by the advise, time and material provided by several experienced and respected experts in the field, mentioned below :

- Sachdeva, Pradeep, Architect, Pradeep Sachdeva Design Associates
- Gandhi, S., Arora, A., Varma, R., Sheth, Y., Sharma, S., Jawed, F., Interface for Cycling Expertise (ICE), Manual for Cycling Inclusive Urban Infrastructure Design in the Indian Subcontinent, 2009
- Aggarwal, Anjlee, Executive Director, Samarthayam, Guidelines for Inclusive Pedestrian Facilities, Report for IRC, 2009
- Transport Research And Injury Prevention Programme (TRIPP), IIT Delhi, BRT Design Specifications, 2009
- Choudhury, Anumita R., Associate Director, Centre for Science and Environment, Footfalls: Obstacle Course to Livable Cities, Right to Clean Air Campaign, 2009
- Hingorani, Akash, Oasis Designs, Inc.
- INTACH, Delhi Chapter

In due course, a review of Pedestrian Design Guidelines was initiated after 6 months of its publication to include some more chapters related with Storm Water Management, Kerb heights, Slip Roads, Bus Corridors and updates on Signalized left turn lanes, radius of turning movement of left turns, etc. and an overall review was done to incorporate various suggestions received from experts & implementing agencies.

Sh. S.N. Sahai, Chairman of WG-1A and Sh. Ashok Kumar, Commissioner (Plg.) DDA, Co- Chairman of WG-1A have given their complete support with timely advise for revision and completion of this guideline document within a particular time frame. Sh. B. K. Jain, AC (TC&B), DDA has provided necessary guidance/advise, which has helped complete the process of preparing the final document.

Several external consultants have also voluntarily helped in the preparation of drawings and sketches incorporated in the guidelines including Ms. Ran Chen, ui2 International and Mr. Nishant Lall, NilaA Architecture & Urban Design. The document was prepared and finalized by the UTTIPEC Core Team under Ms. Paromita Roy, Sr. Consultant with the assistance of in-house consultants and interns from SPA with a special mention to Mr. Sahil Sasideran, during the period from 19th May to 19th July.

All the other Sub-group members and special invitees who have attended various meetings of Working Group I-A and the Sub-group, have provided necessary inputs for formulating and finalizing the Street Design Guidelines. List of references is placed at Annexure-II. List of Working Group members, sub-group members, UTTIPEC Core Consultants team and other participants/special invitees is placed at Annexure-III.

Shri Ashok Bhattacharjee,
Director (Plg.) UTTIPEC,

Streets are valuable public spaces as well as movement corridors.

Design of Streets is a function of the Street Hierarchy and Adjacent Landuses.

Certain Street Design Components are non-negotiable.
These components and additional guidelines for world class streets – have been outlined in this document.

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Annexure III Working Group 1-A Members, Experts, Special Invitees and others.

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1. Need for Street Design Guidelines

Need and prospective Benefits of Pedestrian Design

Inadequate space for pedestrians

Inadequate space for pedestrians

Inappropriate kerb heights

Missing sidewalks!

Missing sidewalks

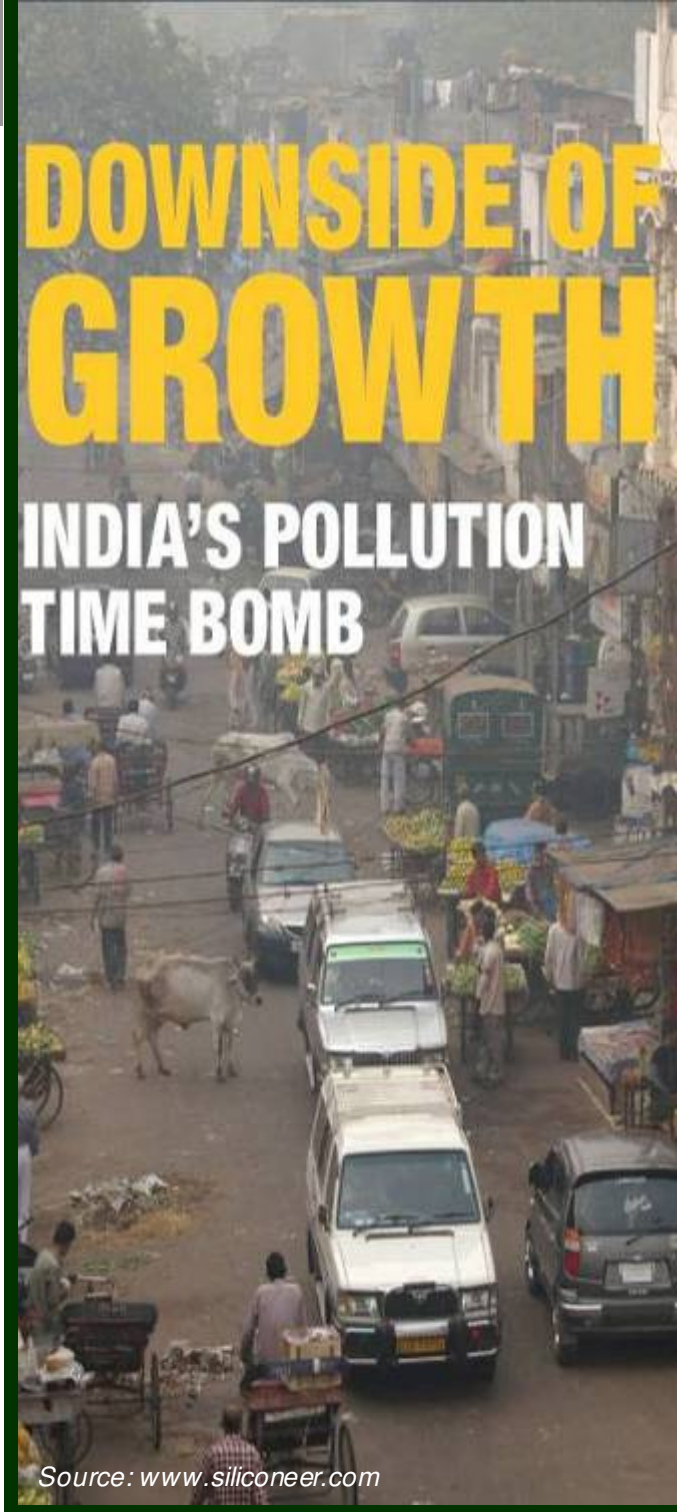
Encroached space by trees, utilities

Inadequate Amenities.

Need and prospective Benefits of Pedestrian Design

Increased Pedestrian Design consideration in Streets would provide:

- **Increase in comfort** for current walking population.
- Comfortable **last mile connectivity** from MRTS Stations – therefore increased ridership of buses and Metro.
- **Reduced dependency on the car**, if shorter trips can be made comfortably by foot.
- More exercise, so **better health** for people walking.
- **Prioritization of public transport** and non-motorized private modes in street design
- Reduced car use leading to **reduced congestion and pollution.**
- **More equity** in the provision of comfortable public spaces and amenities to all sections of society.



Source: www.siliconeer.com

Consequences:

Only 14% of the city drives, yet most of the road space is occupied by them.

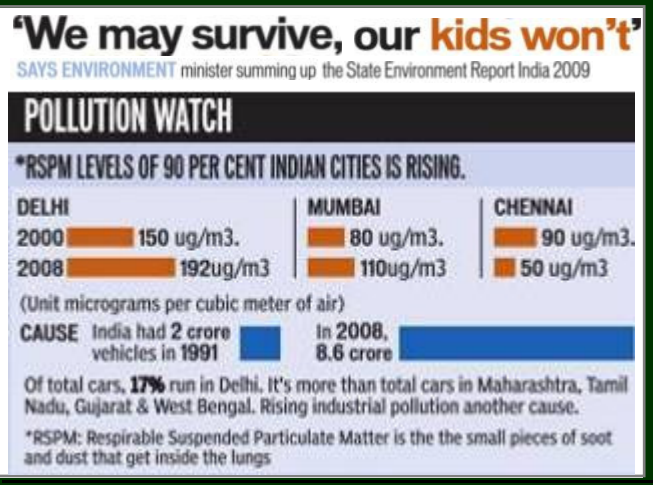
Roads in Delhi have been primarily designed to increase the speed and ease of movement of car users.

Car-oriented design priority and discouragement of walking through inadequate design – has discouraged people from walking and in turn encouraged car-dependency.

The following are the consequences:

Delhi has more cars than the total cars in Maharashtra, Tamil Nadu, Gujarat & West Bengal.

Pollution levels in Delhi are almost double of Mumbai, a city more populated than Delhi.

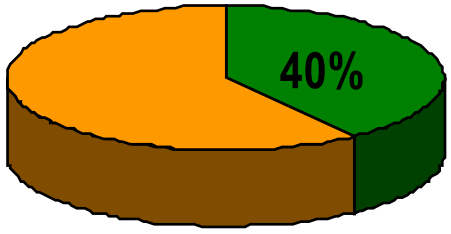


Current Facts: Modal Share of Delhi

MODE	% of PERSON TRIPS		
	WITH WALK TRIPS (2007-08)		
•CAR/TAXI	9.09		
•2W	14.07	23	Motorized Private Transport
•AUTO RICKSHAW	2.36		
•BUS	27.12		
•METRO	2.66		
•TRAIN (IR)	0.42	33	Public/ Para-Transport
•BICYCLE	4.46		
•CYCLE RICKSHAW	5.16		Non-motorized
•WALK	34.67	44	Public/ Private Transport
TOTAL	100		
TOTAL TRIPS/DAY	219.87 LAKH	100	

Source: Anon 2008, Transport Demand Forecast Study: study and development of an Integrated cum Multi Modal Public Transport Network for NCT of Delhi, ***RITES, MVA Asia Ltd, TERI, May 2008***

- **34% of the population engages in" Walk-only" trips** for their daily travels, needs or errands.
- **Only 14% population of Delhi rives private cars.**



- **40% of the total Road Length of Delhi has NO Sidewalks!***

  And the ones having sidewalks, lack in quality in terms of surface, width and geometrics.*

*Source: RITES Transport Demand Forecast Study: May 2008

Why is promoting of Walking and Cycling Important?

The Data below shows that even in Cities where Public Transport availability and usage is high, the modal share of private transport is still high, due to low walking and cycling use.

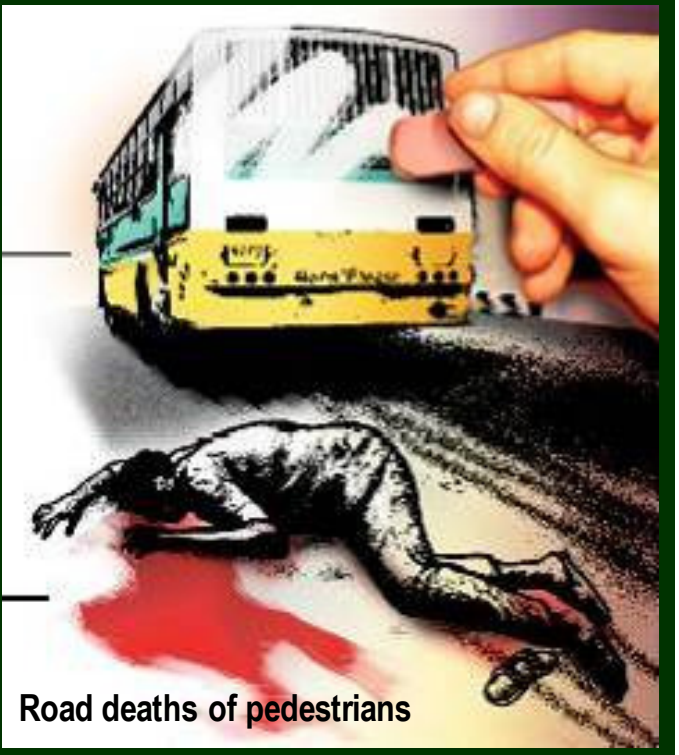
Therefore promoting of walking and cycling infrastructure helps shift short trips (1 – 4 km trips which constitute 60% of all trips in Delhi) to walk or non-motorized modes, thus bringing down private car dependency.

Relationship between Private Vehicle Use and Walking & Cycling friendly City:

	Modal share, percent		
City	Car + MTW	PT	W&C
Bristol, UK	65	12	23
Leeds, UK	61	36	3
Nantes, France	58	14	28
Helsinki, Finland	54	20	26
Marseille, France	53	12	35
Edinburgh, UK	52	29	19
Newcastle, UK	48	19	33
Brussels, Belgium	44	18	38
Frankfurt, Germany	42	21	37
Stuttgart, Germany	36	25	39
Amsterdam, Neth's	32	16	52
MTW motorized two wheeler, PT – Public transport W&C – Walking and cycling			
Delhi, India	23	33	44
Mumbai	15	52	33
Kolkata	12	58	30
Chennai	31	39	30

India already has high mode share for Non-motorized Modes. This should therefore be encouraged and made safer through design and adequate space allocation.

Data Source: IIT Delhi, 16.08.2010;
Indian Data Source: Wilbur Smith Associates, Ministry of Urban Development, Govt. of India, 2007



Road deaths of pedestrians

Who walks in Delhi?

Walking for work, education and services…..

Of all education trips – 58% walk trips
Service and business trips – 31% walk trips (RITES 2001)

Walking and urban poor…….

About 60% of people live in low income localities. An earlier estimate shows 22% of people with less than Rs 2000/month income walk in Delhi. Moving slums out to periphery had sharply reduced women employment as accessibility became a problem

Disability and walking……

Samarthyam survey: 58% of the disabled found steps, ramps, difficult to negotiate; 45% of elderly found steps and ramps daunting; 20% found uneven, narrow sidewalks difficult. Engineering guidelines for persons with disabilities are not implemented.

Urbanity and life style

Correlation between active transportation (walking and cycling) and obesity: China – 1.8kg weight gain after and twice as likely to get obese for a Chinese who acquired a car. King County, US – people weigh 7 pounds less on an average in walkable neighbourhoods

Unacceptably high accident rates……..

Total number of road accidents are very high in Delhi – 2.5 times higher than that of Kolkata, 2.1 times higher than Chennai – personal vehicles cause most of these accidents...

Nearly half of fatal accidents in Delhi involve – **pedestrians.**

Source: Walkability Roundtable, Centre for Science and Environment, July 2009

2. Existing Frameworks

Existing Frameworks and Legislation

Current Laws and Guidelines that legislate "right to walk" and "right to road space" of Pedestrians:

A. Current IRC Guidelines for Pedestrian and Cycle track design provide basis standards for pedestrian and cycle oriented design but need more augmentation.

B. **National Urban Transport Policy 2006 recommends:**

i. Integrated land use and transport policy

ii. Equitable distribution of road space between all road users

iii. Priority to the use of public transport

iv. Priority to non-motorized modes

C. **Masterplan of Delhi 2021 specifies:**

i. All roads should be made pedestrian, disabled and bicycle friendly.

ii. Provision of adequate pedestrian facilities.

iii. Removal of encroachments from sidewalks.

iv. Provision for introducing cycle tracks, pedestrian and disabled friendly features in arterial and sub-arterial roads.

v. In urban extension, cycle tracks should be provided at the sub-arterial and local level roads and streets.

vi. In specific areas, like the Walled City / Chandni Chowk / Sadar Bazar / Karol Bagh / Lajpat Nagar and Trans Yamuna Area, the use of cycles/rickshaw as a non-motorised mode of transport should be consciously planned along with pedestrianisation.

vii. On all roads with ROW greater than 30 m exclusive bus lanes will be planned to implement the Bus Rapid Transit System (BRTS) in a phased manner to cover the whole city.

D. **EPCA, Supreme Court directive on increased use of Public Transport in Delhi.**
"Over the years, it has become clear that each city is fighting a losing battle against air pollution and growing congestion — because of the growing numbers of vehicles. Economic progress of our cities will depend on their environmental health. A turnaround is only possible when cities recognize the need for a transition to public transport and adopt it."

The following UTTIPEC, DDA Guidelines will work towards augmenting and strengthening the above city level targets and frameworks.

Existing Frameworks and Legislation

Many City level Laws converge to safeguard the safety of pedestrians:*

- Central Motor Vehicles rules (CMVR) 1989 Safety Rules provide passive protection for pedestrians, stating that **motorists cannot enter pedestrian way and are liable to penalty.**
- Indian Penal Code (sec 283), sec 34 of Delhi Police Act -- **Obstruction in public space punishable.**
- Urban street vendor policy, 2007, to protect livelihood rights – recommend Guidelines for proper vending zones, as they are service providers on sidewalks…
- The National Policy on Urban Street Vendors, 2009, approved by the Central government, recognizes street vendors (or micro-entrepreneurs) as "an integral and legitimate part of the urban retail trade and distribution system." The national policy gives **street vendors a legal status and aims at providing legitimate vending/hawking zones** in city/town master or development plans.
- Police Act provides for **penalty for jaywalking.**
- Design and engineering guidelines by Indian Road Congress (IRC) are currently being revised and updated.
- Persons with Disabilities Act 1995 (Sec 44) recommends guidelines for the disabled persons.

The following UTTIPEC, DDA guidelines will work towards augmenting and strengthening the above city level targets and frameworks.

**Source: Walkability Roundtable, Centre for Science and Environment*


Cars parked on pavements are liable to penalty


Adéquate & fréquent crosswalks are needed


Hawkers are legal

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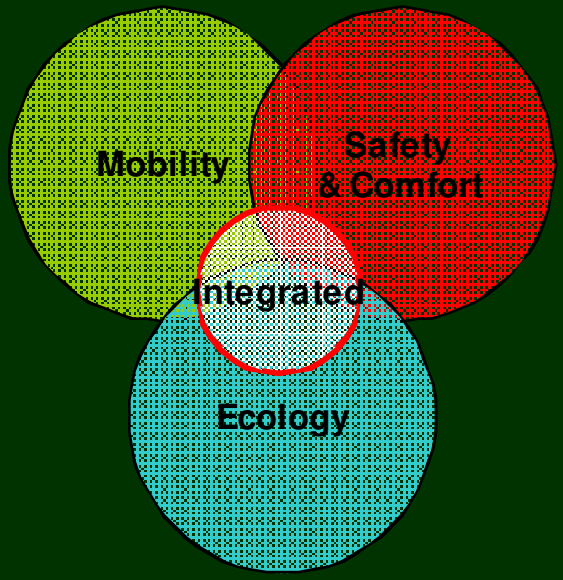
3. Essential Goals

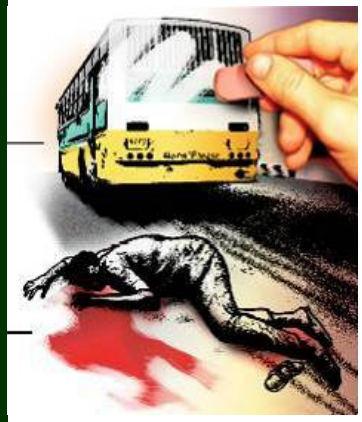
GOALS FOR "INTEGRATED" STREETS FOR DELHI:



GOAL 1:

MOBILITY AND ACCCESSIBILITY –

Maximum number of people should be able to move fast, safely and conveniently through the city.



GOAL 2:

SAFETY AND COMFORT –

Make streets safe clean and walkable, create climate sensitive design.

GOAL 3:

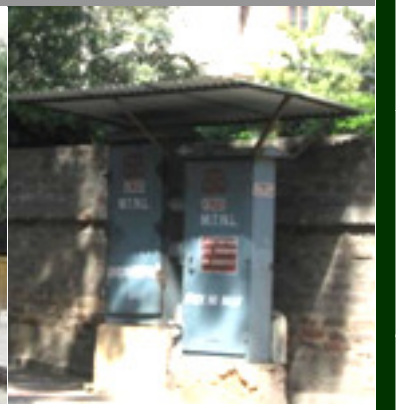
ECOLOGY –

Reduce impact on the natural environment; and Reduce pressure on built infrastructure.

Essential Components of all Streets

Pedestrian sidewalks & crossings

Non motorized vehicles



Utilities

Physically challenged

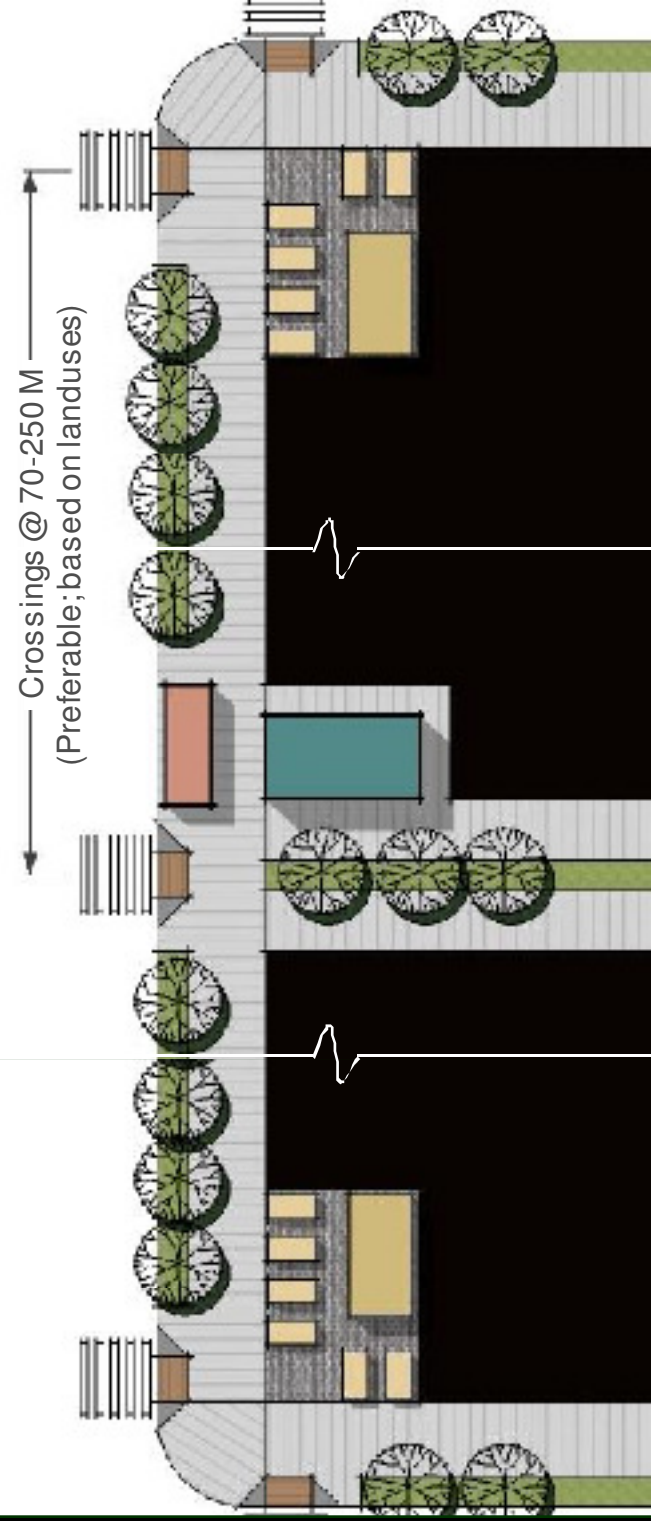
Motorized private vehicles

Public Toilets

Trees

Rainwater harvesting

Shaded Bus stops



Mobility Goals:

To ensure preferable public transport use:

1. To Retrofit Streets for equal or higher priority for Public Transit and Pedestrians.
2. Provide transit-oriented mixed landuse patterns and redensify city within 10 minutes walk of MRTS stops.
3. Provide dedicated lanes for HOVs (high occupancy vehicles) and carpool during peak hours.

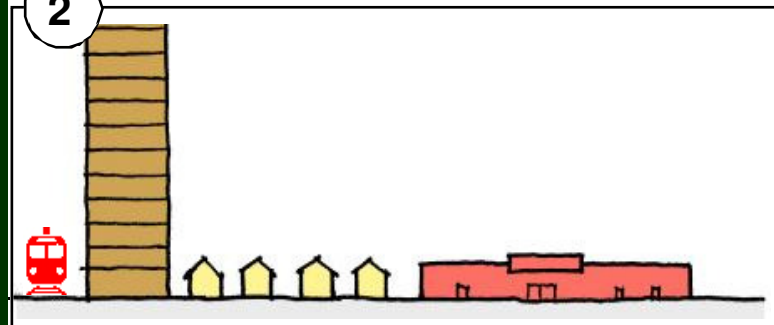
Ensure preferred public transport use

1

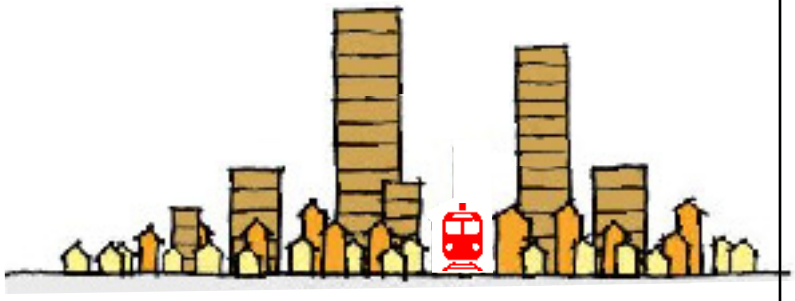
Car-dominated street, uncomfortable for pedestrians.

Street with equal priority & comfort for all users.

2



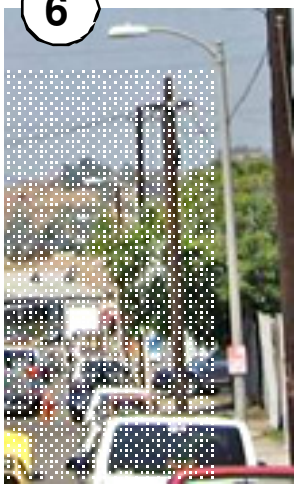
Segregated Uses, Random density

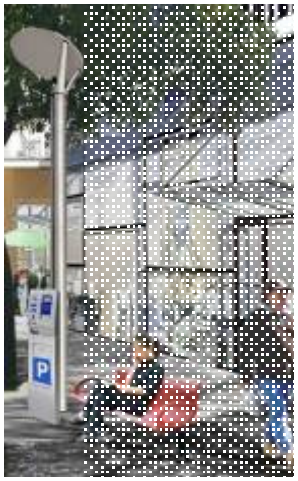


Mixed Uses, Transit-Density Pyramid

3

Provide safety, comfort and amenities to all users





Safety, Comfort Goals:

To ensure pedestrian safety:

4. Create "eyes on the street" – by removing setbacks and boundary walls and building to the edge of the street ROW. This would allow people from inside to look out on to the pavement, thus discouraging misbehavior, shady corners, peeing, etc.)
5. In case enclosure of sites is required, transparent *fencing* should be used above 300 mm height from ground level.
6. Require commercial facades to have minimum 30% transparency.
7. Provide adequate Street Lighting for pedestrians and bicycles.
8. Create commercial/ hawking zones at regular intervals (10 minute walk from every home in the city) to encourage walkability, increase street activity and provide safety. (e.g. Mumbai, Shanghai)

Safety, Comfort Goals:

For climatic comfort:

8. *Trees* are an essential component for all streets – to provide shade to pedestrians and reduce solar gain.

9. *High albedo* (diffuse reflectivity) materials for paving reduces urban heat island effect.

10. Built to Pavement edge buildings with overhangs and arcades provide excellent protection to pedestrians.

Provide climatic comfort

8

9

10

Provide universal accessibility and civic amenities

11

12

Signage | *Pedestrians* | *Street furniture/ Utilities*

13

14

Handicapped Ramps, Tactile Paving

Safety, Comfort Goals:

To ensure universal accessibility and amenities for all street users:

11. Provide at-grade crosswalks (and overpasses on highways) at maximum intervals of ~70-250 M, aligning with location of transit stops, type of street / landuse activities and neighboring building entries and destinations.
12. Provide Dustbins, postboxes, signage and other public amenities at street corners for high usability.
13. Provide Accessible Public Toilets at every 500 -800 M distance – preferably located close to bus stops for easy access by pedestrians and public transport users.
14. Follow universal accessibility design standards to make public streets & crosswalks fully navigable by the physically handicapped.

Ecological Goals:

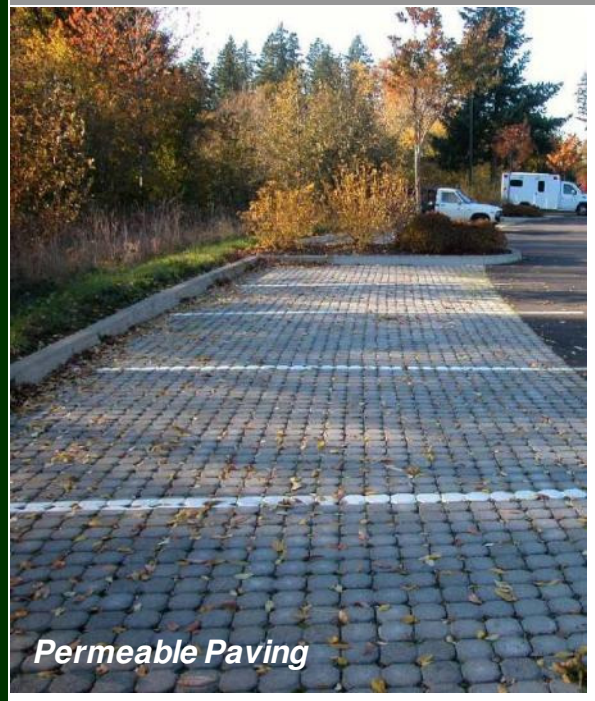
To reduce urban Heat Island Effect and aid natural storm water management:

15. Decrease impervious surfaces through permeable paving, tree planting zones, etc. to increase ground water infiltration & prevent seasonal flooding.

16. Integrate Natural Storm Water filtration and absorption into street design through bio-filtration beds, swales and detention ponds.

17. Decrease Heat Island Effect (HIE) by increasing greenery, planting trees, using reflective paving, etc.

Reduce heat island effect & aid storm water management.



Permeable Paving

15

16

Infiltration beds

17

Bio-filtration beds

4. Street Hierarchy of Delhi with Categorization by Function.

Road Network Hierarchy of Delhi:

National Urban Transport Policy 2006 recommends:

i. Equitable distribution of road space between all road users

ii. Priority to the use of public transport

iii. Priority to non-motorized modes

Masterplan of Delhi 2021 specifies:

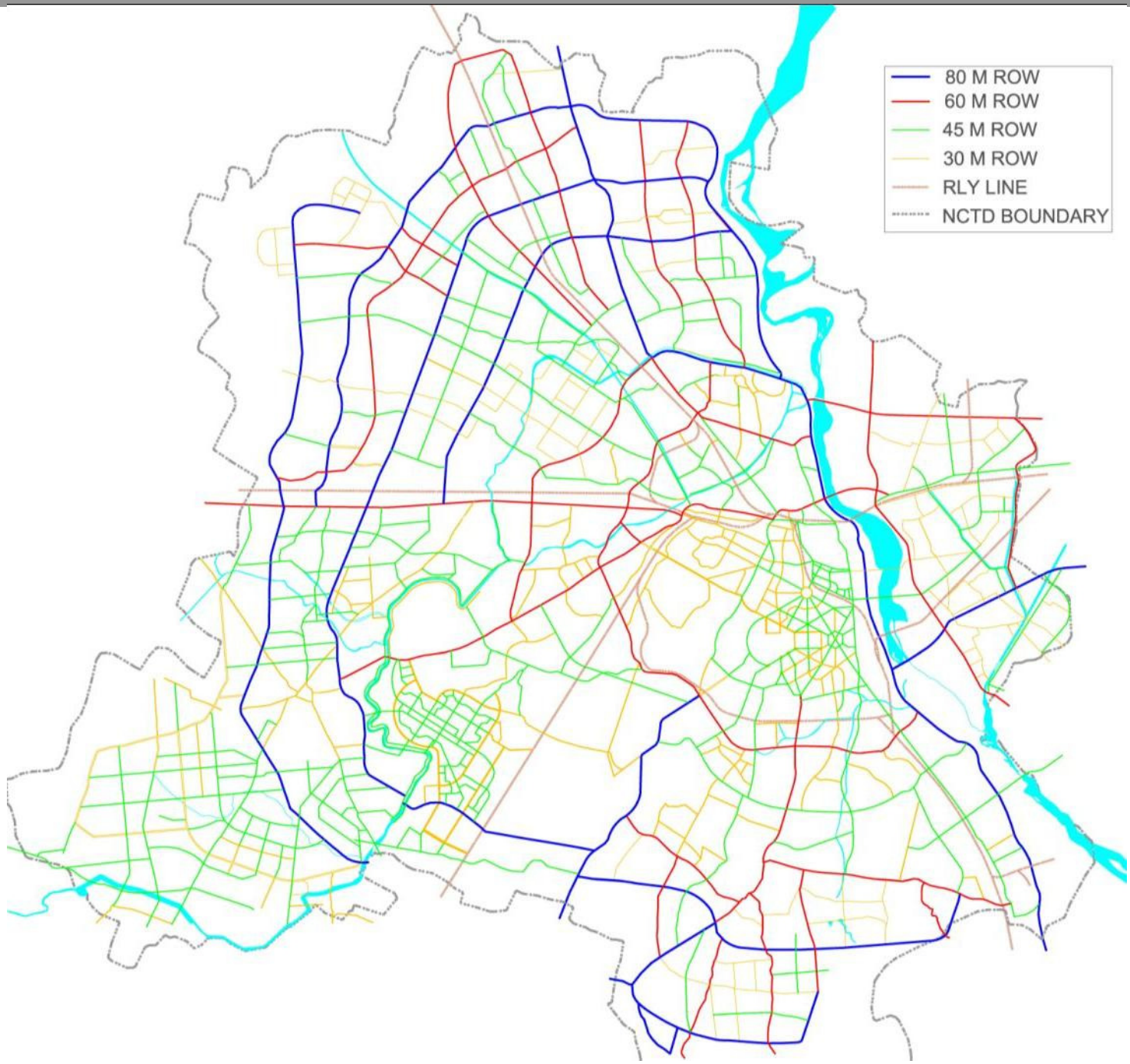
i. All roads should be made pedestrian, disabled and bicycle friendly.

ii. Provision of adequate pedestrian facilities.

iii. Provision for introducing cycle tracks, pedestrian and disabled friendly features in arterial and sub-arterial roads.

iv. In urban extension, cycle tracks should be provided at the sub-arterial and local level roads and streets.

v. On all roads with ROW greater than 30 m exclusive bus lanes will be planned to implement the Bus Rapid Transit System (BRTS) in a phased manner to cover the whole city.



Drawing prepared by UTTIPEC WG-IA, DDA, Nov 2009

Masterplan-2021 Road Hierarchy:

1. National Highways.

The recommended minimum right of way (ROW) is **90 meters**, wherever possible. However, within the city it shall not be less than 60meters. All the National Highways within the NCTD shall be access controlled upto the Delhi Border.

2. Arterial Roads.

These include primary roads with access control and other primary roads.

i) **Primary Roads:** Vehicular routes carrying heavy volumes of traffic will generally have free / stable flow conditions with controlled access. The recommended ROW in existing urban area is **60-80 m.** and minimum 80 m. in the proposed urban extension. While designing roads with 30m. ROW and above, provision should also be made for public mass rapid transport system, which may include BRT. Present ring road and outer ring road to be converted to access controlled arterial roads. Cycle tracks should also be constructed along all arterial roads wherever possible.

ii) **Other Primary roads:** Vehicular routes carrying heavy volumes of traffic, BRT route may also be allowed on these roads. The recommended ROW in existing urban area is **45-60 M**. and minimum 60 m. in the proposed urban extension. Cycle tracks should also be constructed along all other primary roads wherever possible.

3. Sub Arterial (Collector) Streets.

These include primary and secondary collector streets.

(i) **Primary Collector:** These roads will connect major arterial roads and inter residential district collectors. The recommended ROW in existing urban area is **30-40 M**. and minimum 45 M. in the proposed urban extension. In addition to this, a separate cycle track should be provided wherever possible.

(ii) **Secondary Collector:** These roads are intended to collect traffic from local streets within one residential district. The recommended R/W in existing urban area is **18-24 M.** and minimum 30 M. in the proposed Urban extension.

4. Local Streets.

These are intended for neighbourhood (or local) use on which through traffic is to be discouraged. The suggested ROW is **12 to 20 m**. in the existing and proposed urban area. These roads should be made pedestrian and bicycle friendly by using modern traffic calming designs to keep the speeds within limits as per design.

Exclusive Pedestrian Only Streets (6 M and less) as per the provisions in MPD 2021 be identified area by area, by the local bodies/ road owning agencies.

1. **National Highways.**
   Only have an inter-city role. When National highways pass through Urban Areas, they become Urban Arterials.

2. **Arterial Roads.**
   Provides long distance mobility between various parts of the city.

3. **Sub Arterial (Collector) Streets.**
   Provides local connections between neighbourhoods and also connects neighbourhoods to Arterial Roads.

4. **Local Streets.**
   Dominant function is to provide local connectivity. Can provide connections between neighbourhoods with dominance to walking and non-motorized movement.

5. **Exclusive Pedestrian & NMV Only Streets**
   Where pedestrian and non-motorized transport are the dominant mode. Particularly applicable to intensely commercialized areas.

Design Principles and Functional Characteristics

Major Street Design Principles:

1. **Safety** of all modes and **Universal Accessibility** of all Streets.
2. **Priority** to public transport users.
3. **Climatic comfort** essential for all road users. Planting of deciduous trees along all footpaths and non-motorized lanes is essential
4. **Ecological design** to minimize environmental impacts like urban heat island effect, storm water runoff, etc.
5. **Amenity** provisions and facilities for all road users is mandatory on all roads, to ensure safety, usability and vibrancy of the street. Therefore designated spaces to be provided for amenities like hawkers, public toilets, street lights, utilities, para-transport drop-offs, etc.
6. **Segregation between modes (by speed)** to be provided if difference in desirable speed of different modes becomes more than 10 km/hr. For example, In areas with high volume of non-motorized through traffic (cyclists), speed of cyclists may be at or above 15km/hr, while speed of pedestrians is below 5 km/hr. So then segregation between the spaces allocated to both is required. Similarly, when desirable speed of motorized traffic is above 25 km/hr and maximum speed of non-motorized traffic is only 15 km/hr, it is required to spatially segregate the two in order to increase safety and efficiency of both types of modes.
7. **Segregation between modes (for priority)** is required when priority is to be provided to public transport and non-motorized transport (both for speed, congestion-free movement, safety and junction clearance) as per principles outlines in the National Urban Transport Policy.
8. **Efficiency** of movement of all modes is to be provided through design.

Masterplan-2021 Road Hierarchy: Categorization*

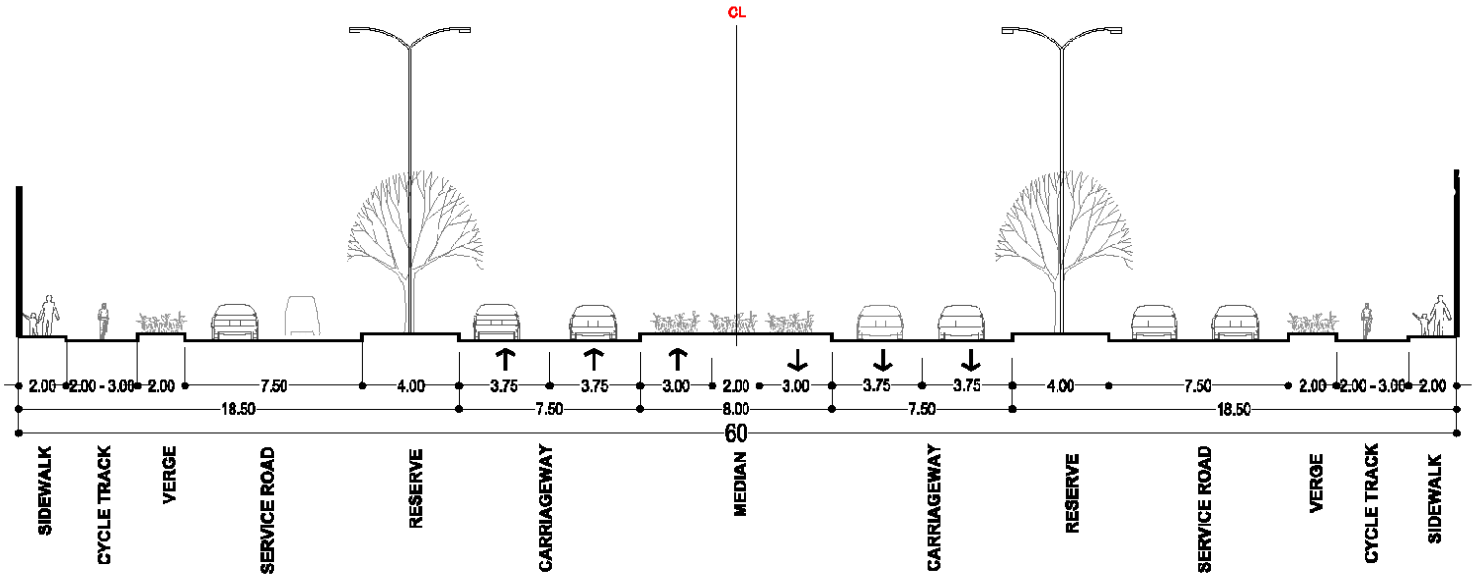
	Primary Arterial	Other Primary Arterial	Primary Collector	Secondary Collector	Local Streets
RIGHT OF WAY	60-80 M	45-60 M	30-40 M	18-24 M	12-20 M
SPEED RANGE	50 – 70 km/hr	30 - 40 km/hr.	20 - 30 km/hr	10- 20 km/hr	10-20 km/hr
SPEED CONTROL	**Enforcement and Traffic Calming required**	**Enforcement and Traffic Calming required**	**Enforcement and Traffic calming required.**	**Traffic calming essential.**	**Traffic calming required**
BUSWAYS FOR BRT	**Segregated busways required where BRT proposed**	**Segregated busways required where BRT proposed**	**Segregated busways required where BRT proposed,** at-grade segregation possible on R/Ws above 36 M	No segregated bus lane; but Road may be designated Bus-NMV only if required	No segregated bus lanes or bus operations required; but Road may be designated Bus-NMV only if required
MOTORIZED LANES	2 to 4 motorized lanes per direction, **min. 3.3 m wide (min. 3.5 for BRT busways)**	2 to 4 motorized lanes per direction, **min. 3.3 m wide (min. 3.3 for BRT busways)**	2 to 3 motorized lanes per direction, **min. 3.1m wide (min. 3.3 for BRT busways)**	No minimum lane width specification.	No minimum lane width specification.
CYCLE/ NMV TRACKS	**Segregated cycle tracks required**; min. 2.5 m wide for two-way movement.	**Segregated cycle tracks required**; min. 2.5 m wide for two-way movement.	Traffic Calming essential where segregated Cycle tracks are not provided; Cycle tracks to be min. 2.5 m wide if block lengths are >250m.	Cycle lanes can work, segregated tracks required where friction & encroachment expected	No special feature for cyclists
SERVICE LANES	**Service lanes required.**	**Service lanes required for low-density residential frontages; for commercial / MU frontages, service lanes not required.**	**No service lane required**	**No service lane required**	**No service lane required**
MEDIANS	**Continuous median;** all openings and intersections accompanied by signals and traffic calming. (no grade separators within city)	**Continuous median;** all openings and intersections accompanied by signals and traffic calming. (no grade separators within city)	**Intermittent or No median;** openings/ intersections accompanied by signals and traffic calming.	**Intermittent or No median required; For roads where need for Median is felt, issue to be brought to UTTIPEC.** Crossings to be traffic calmed.	**No medians;** traffic calmed crossings, or mini roundabouts

NOTE: Lane Widths have been designated based on desired speed of the road category.

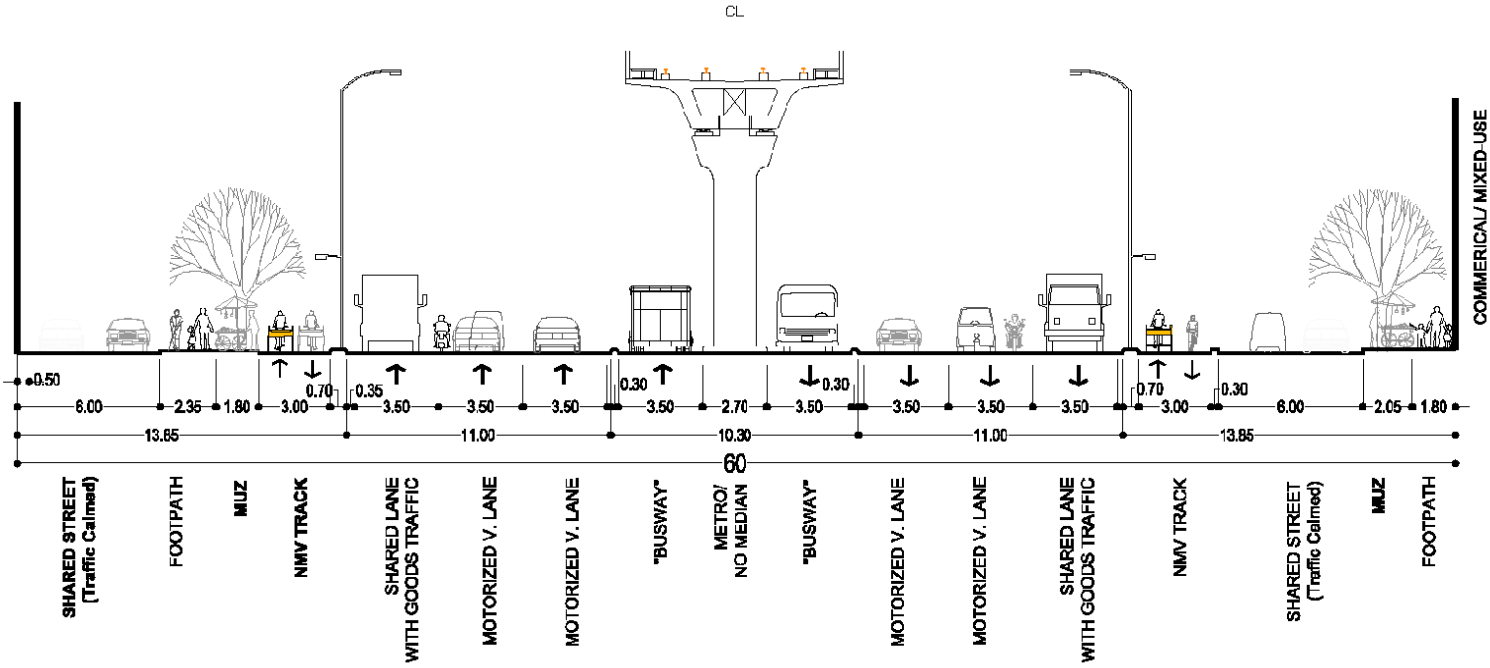
* Guidelines prepared by UTTIPEC, DDA; Revised and Updated in Nov 2010.

60 M Primary Arterial Road – Access Controlled

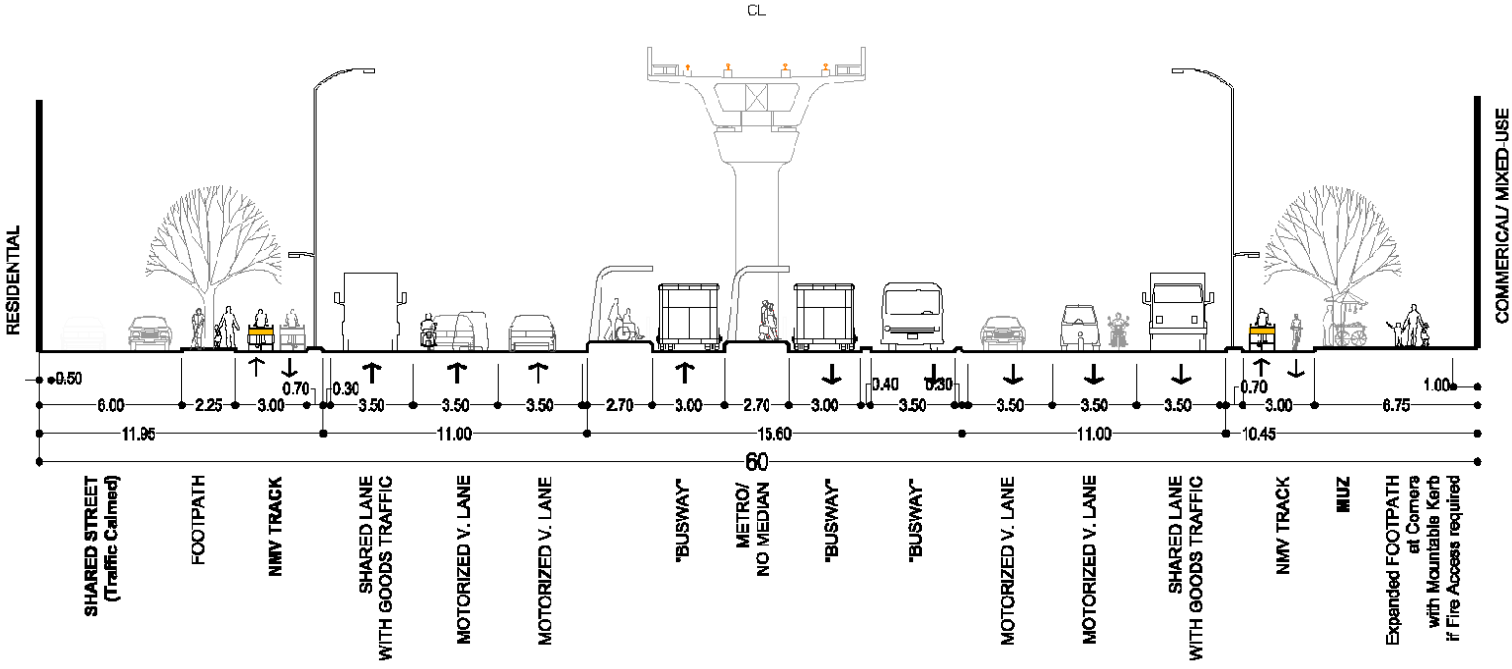
IRC CROSS SECTION ARTERIAL STREET (4 LANE DIVIDED)



UTTIPEC CROSS SECTION - 60 M ROAD WITH BRT / METRO - at MID-BLOCK

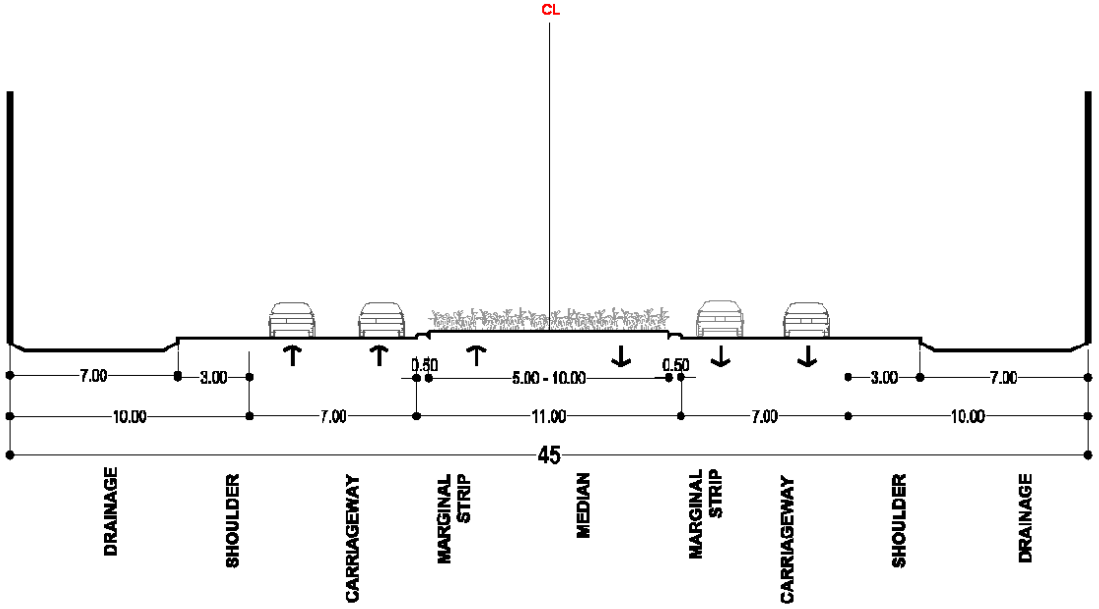


UTTIPEC CROSS SECTION - 60 M ROAD WITH BRT / METRO - at BUS STATION

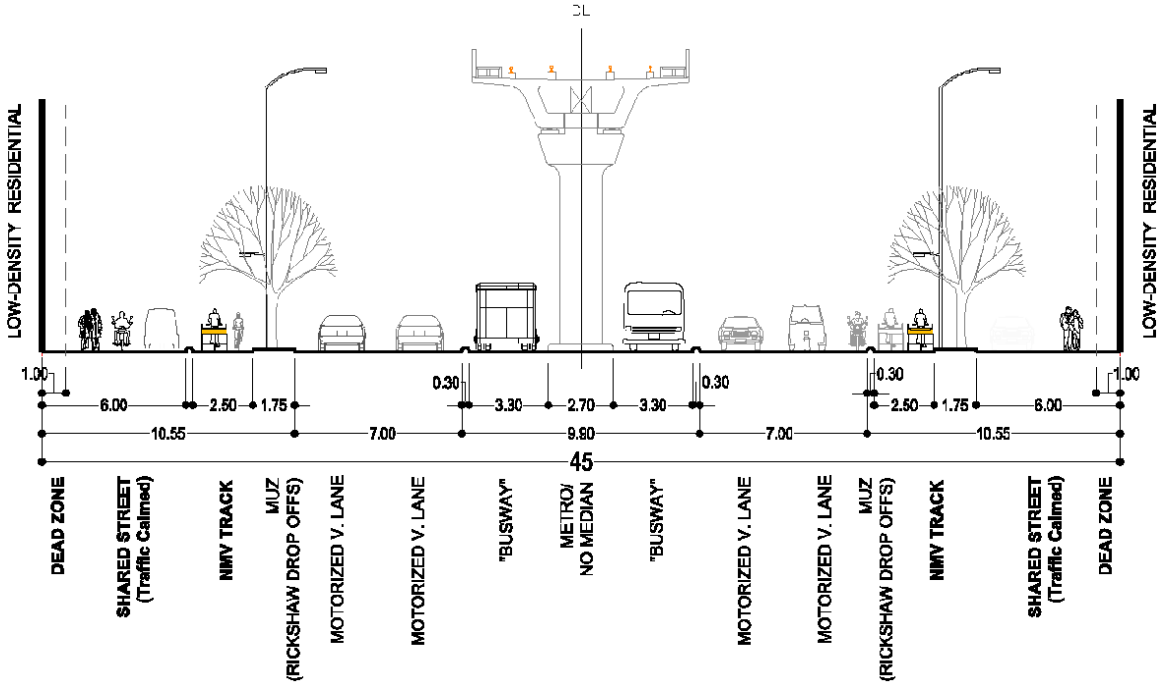


45 M Other Primary Arterial Road – Residential Edges

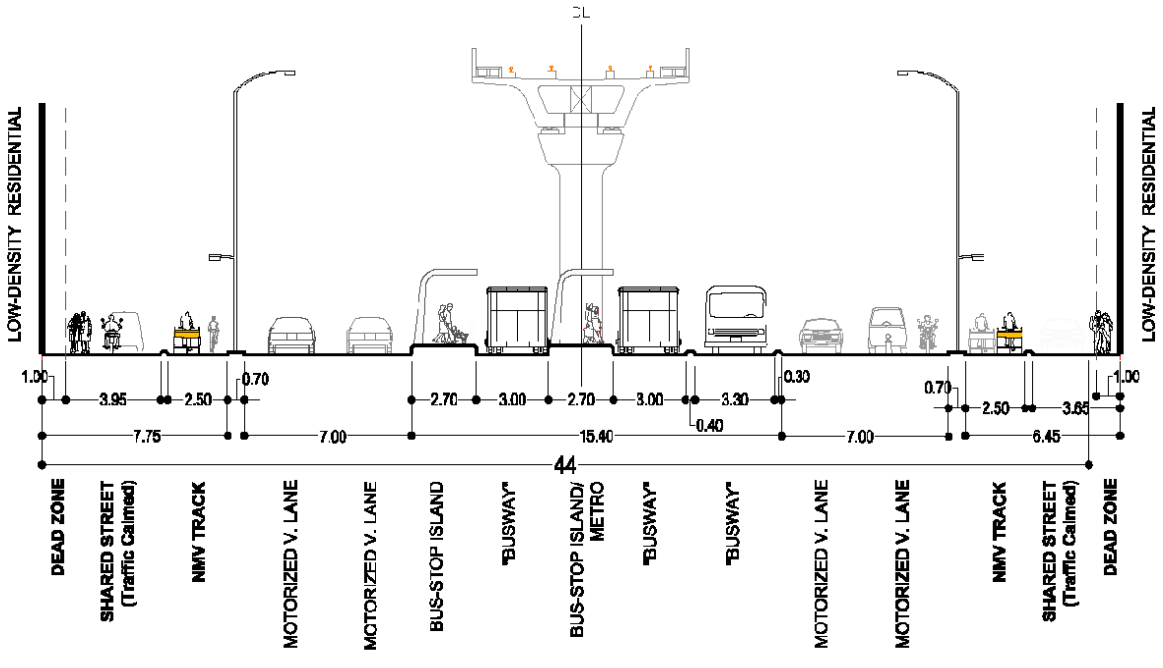
IRC CROSS SECTION EXPRESSWAY (4 LANE DIVIDED)



i) 45 m ROAD WITH BUSWAYS/ METRO at MID-BLOCK - with Service Lane

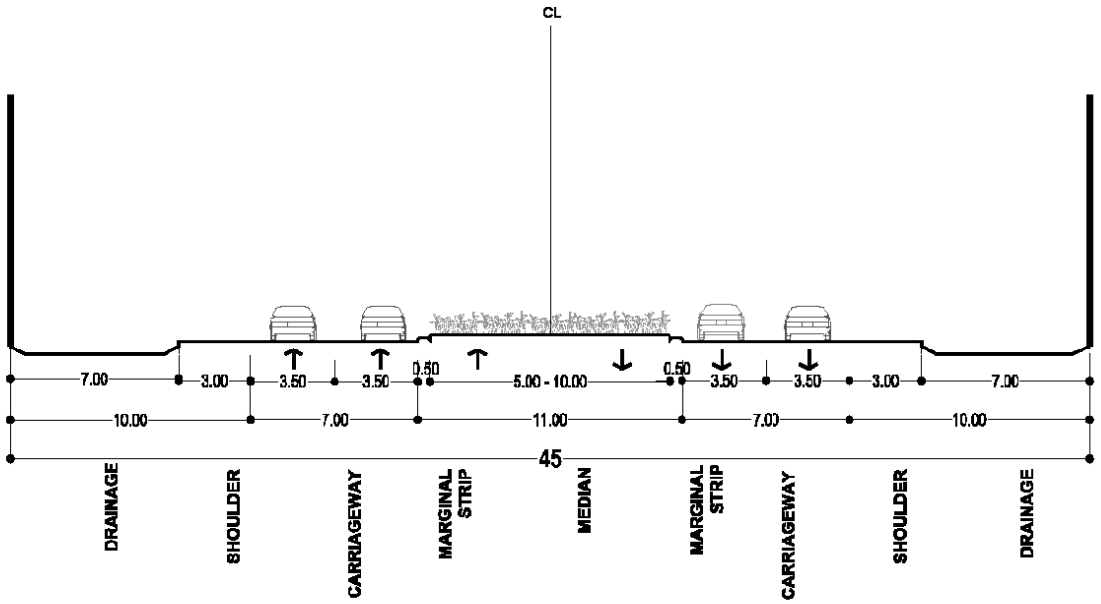


ii) 45 m ROAD WITH BUSWAYS/ METRO at JUNCTION - Residential Frontage

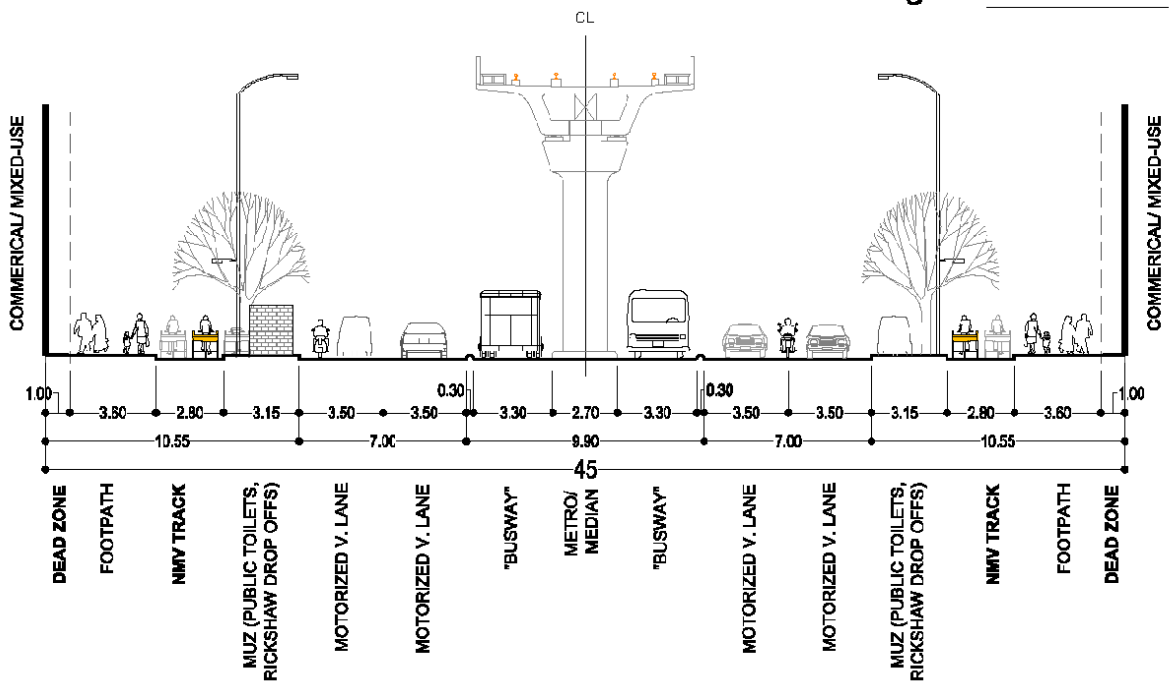


45 M Other Primary Arterial Road – Commercial Edges

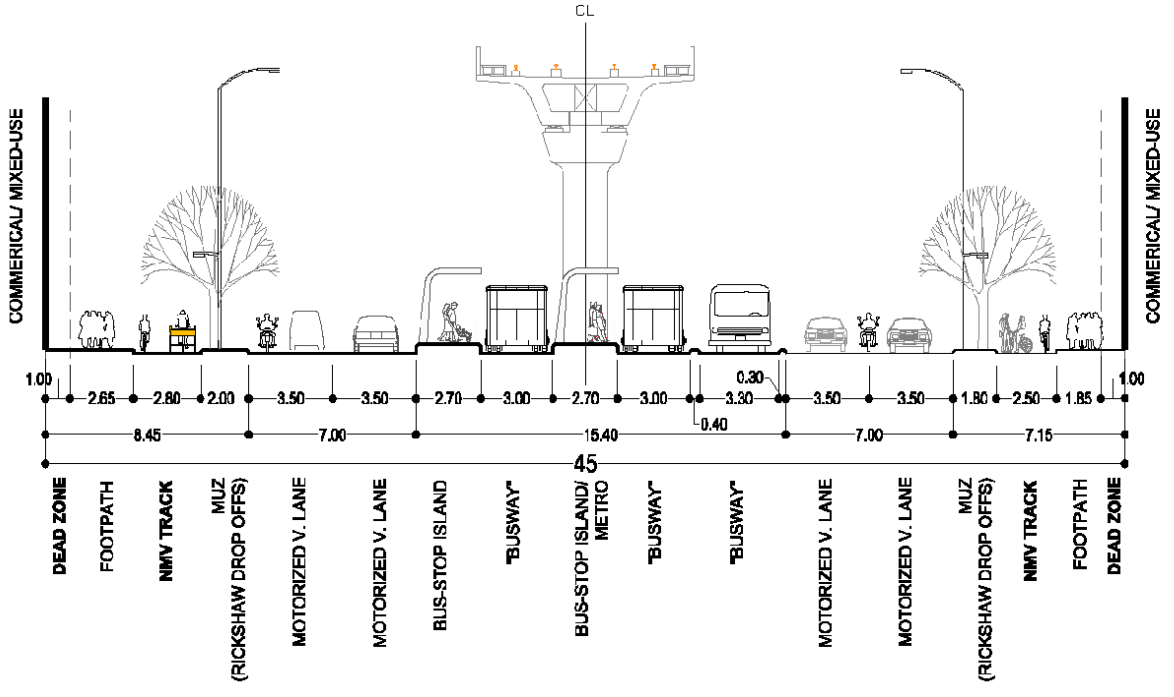
IRC CROSS SECTION EXPRESSWAY (4 LANE DIVIDED)



45 m ROAD WITH BUSWAYS + METRO - Commercial Frontage at MID-BLOCK

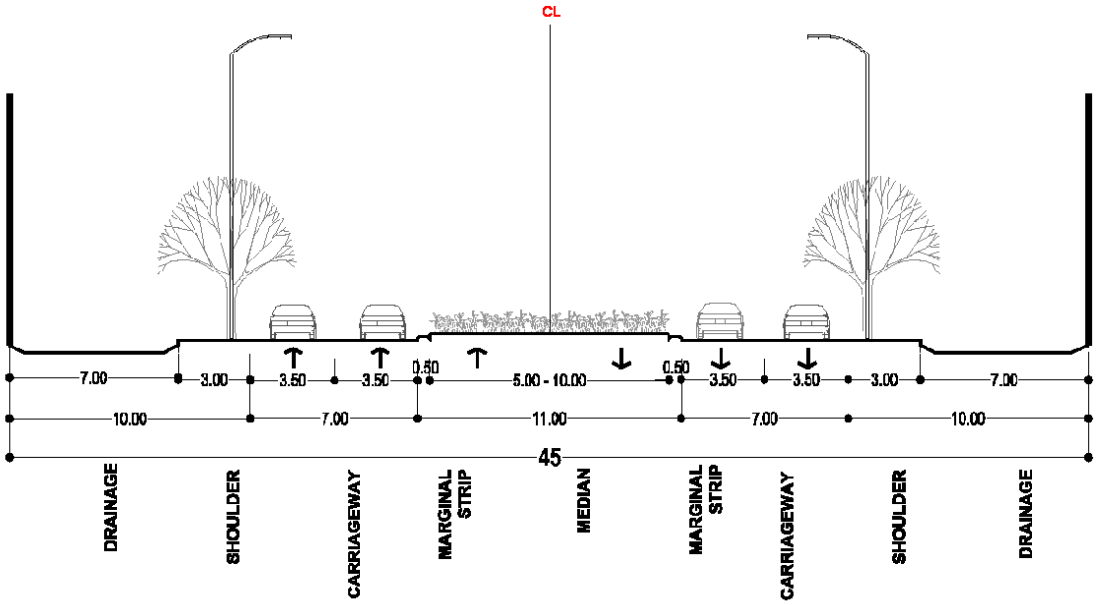


45 m ROAD W/ BUSWAYS + METRO - Commercial Frontage at JUNCTION

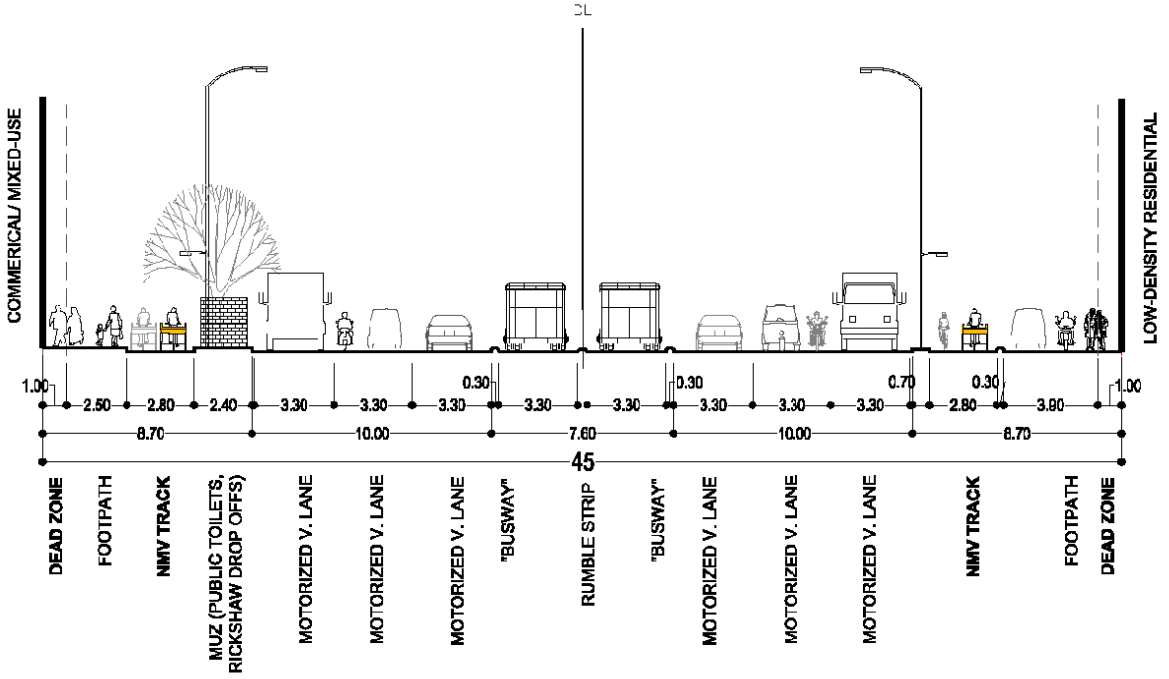


45 M Other Primary Arterial Road – Any Use Edge Condition

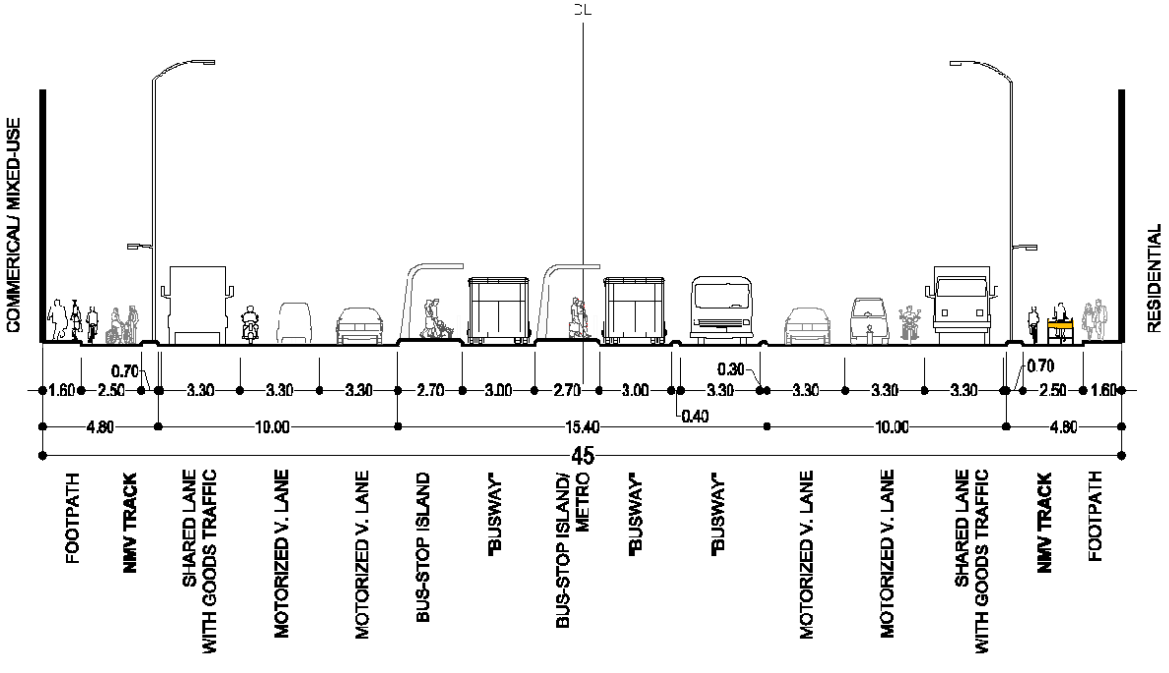
IRC CROSS SECTION EXPRESSWAY (4 LANE DIVIDED)



45 M ROAD WITH BUSWAYS - Commercial or Residential at MID-BLOCK

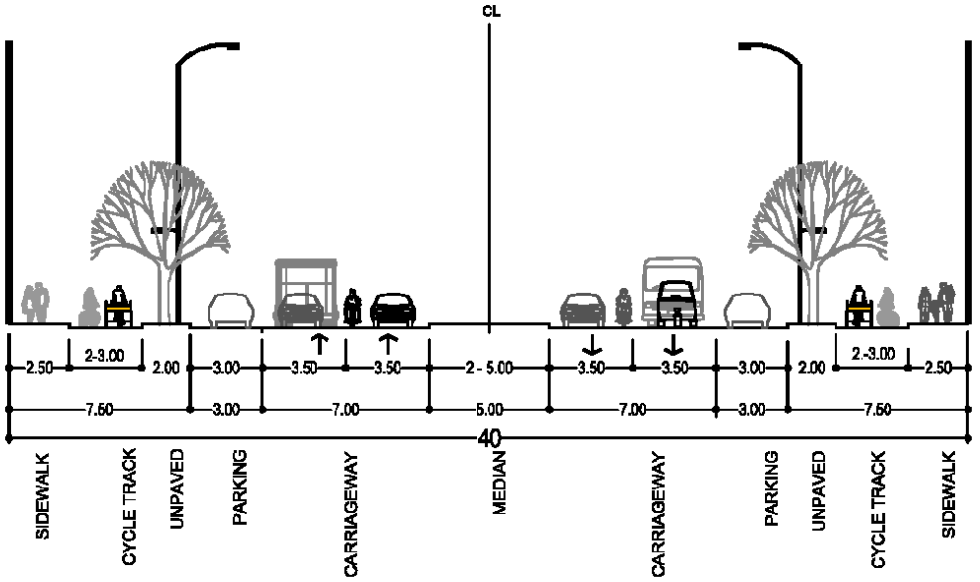


45 M ROAD WITH BUSWAYS - Commercial or Residential at BUS STATION

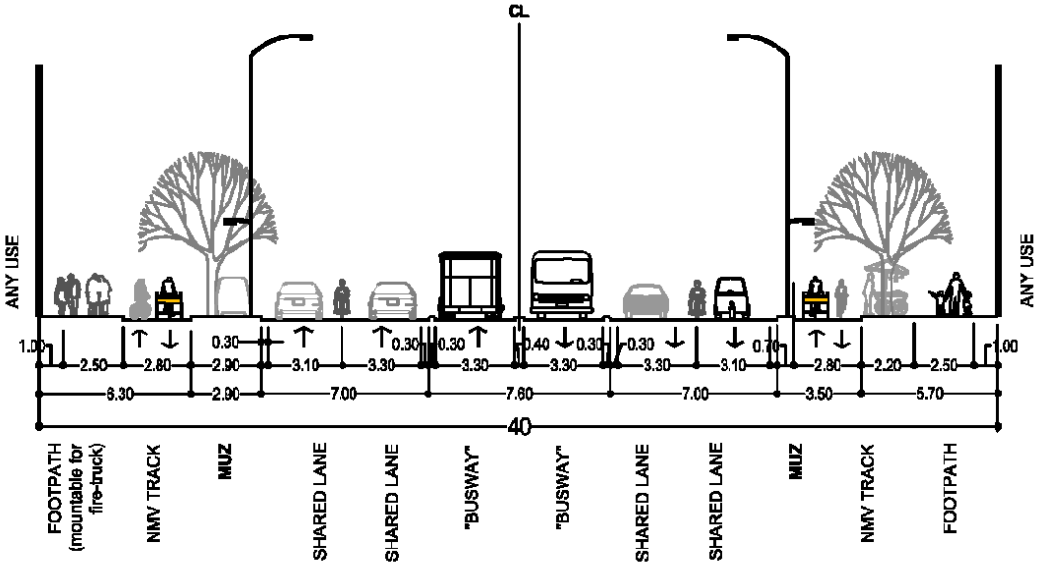


40 M Primary Collector Road – Functioning as Arterial

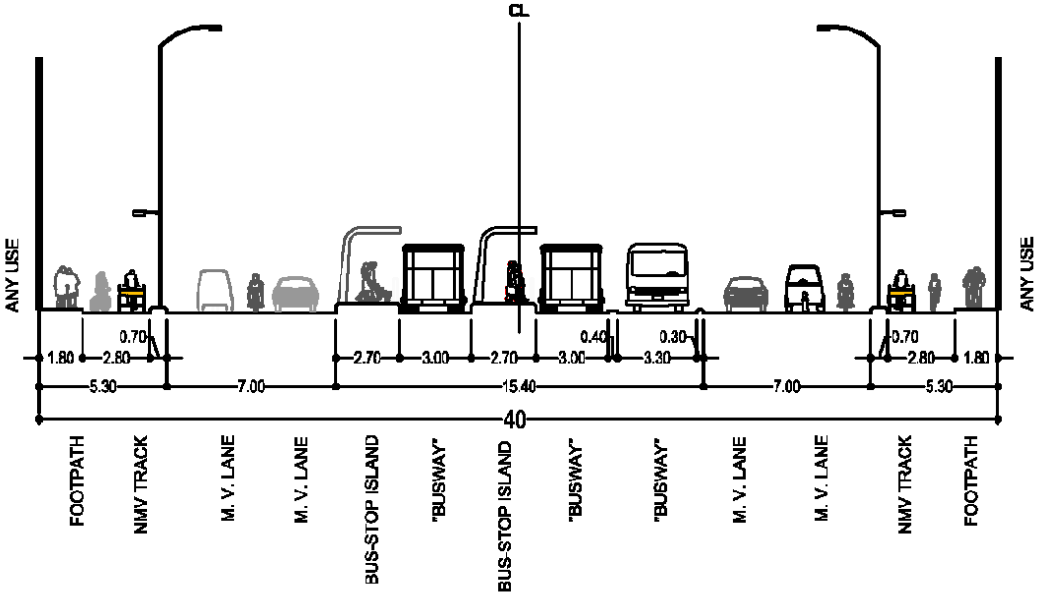
IRC 40 M SUB ARTERIAL STREET WITH EXTRA PARKING LANE (4 Lane Divided)



40 m ROAD WITH BUSWAYS & NMV-TRACKS at MID-BLOCK- Arterial Road Function



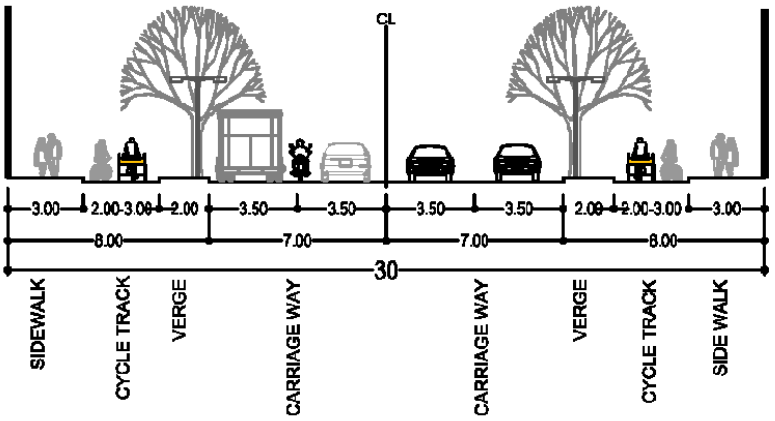
40 m ROAD WITH BUSWAYS & NMV-TRACKS at JUNCTION- Arterial Road Function



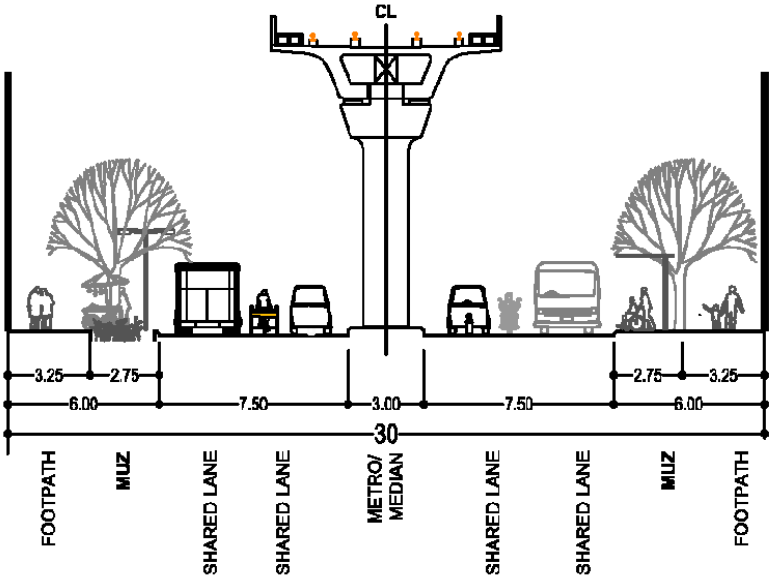
NOTE: Non-motorized lanes/ Cycle Tracks are OPTIONAL on R/Ws below 40m Width.
In case smoother flow of motorized traffic is desired, one "Shared Lane" may be replaced by a dedicated Non-motorized Lane ; to reduce *friction between slow and fast moving vehicles.*

30 M Primary Collector Road

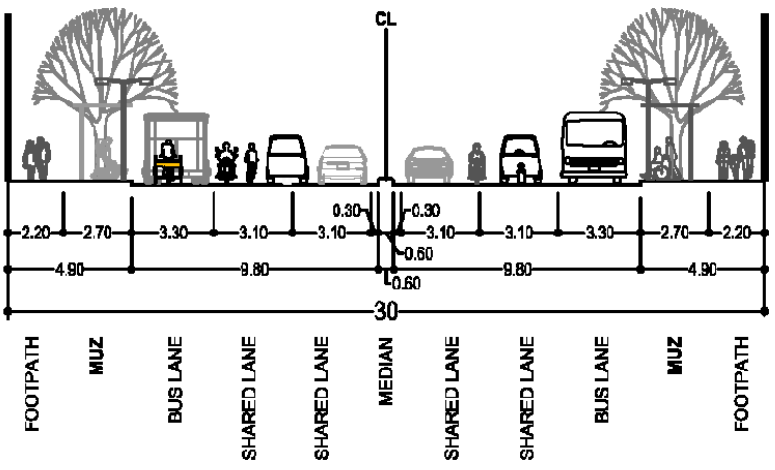
IRC CROSS SECTION - 30 M COLLECTOR STREET
(4 LANE UNDIVIDED)



i) 30 M ROAD WITH METRO & MIXED TRAFFIC (Design Speed <20km/hr)
Collector/ Neighbourhood Road Function



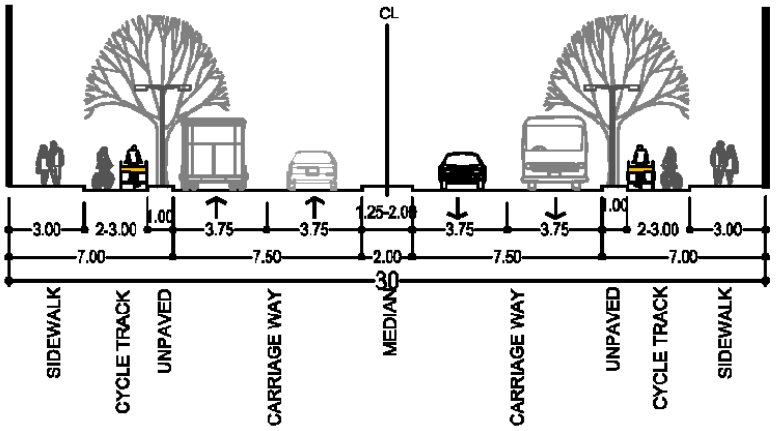
30 M ROAD WITH 6-Lane MIXED (Design Speed <20km/hr)
Collector/ Neighborhood Road Funtion



NOTE: Non-motorized lanes/ Cycle Tracks are OPTIONAL on R/Ws below 40m Width.
In case smoother flow of motorized traffic is desired, one "Shared Lane" may be replaced by a dedicated Non-motorized Lane; to reduce *friction between slow and fast moving vehicles.*

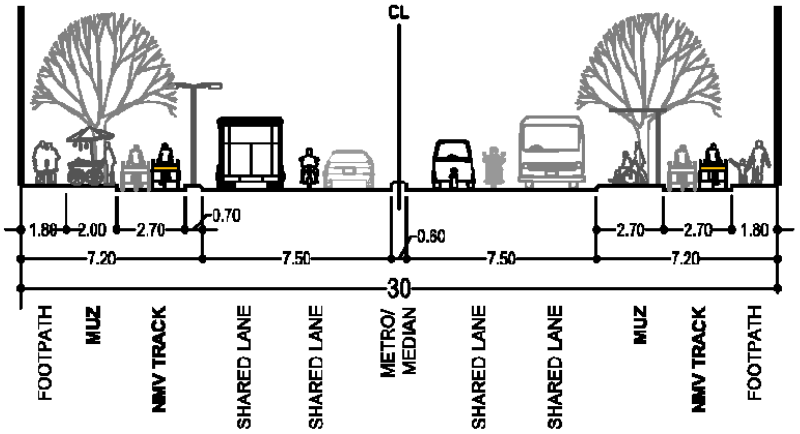
30 M Primary Collector Road – Functioning as Arterial

IRC CROSS SECTION - 30 M COLLECTOR STREET
(4 LANE DIVIDED)



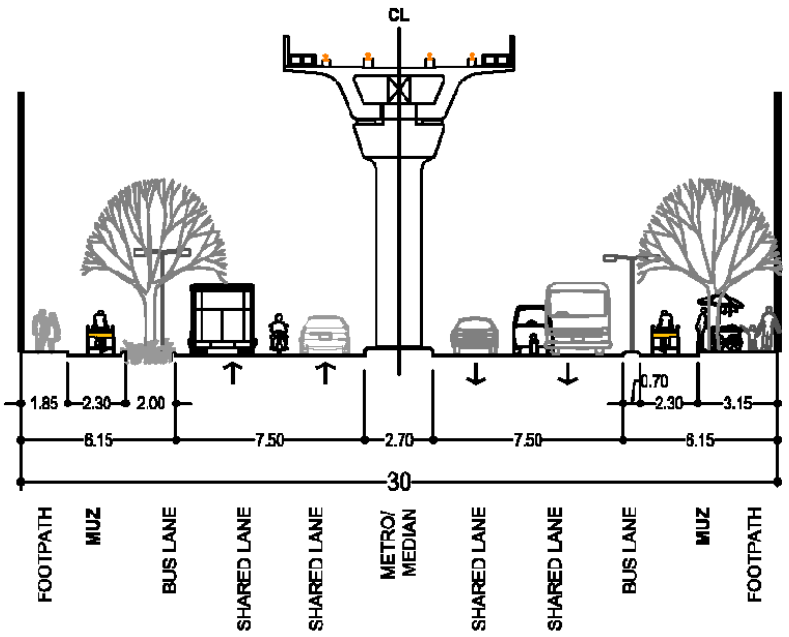
iI) 30 M ROAD WITH SEGREGATED TRAFFIC (Design Speed > 20km/hr)

Arterial Road Function



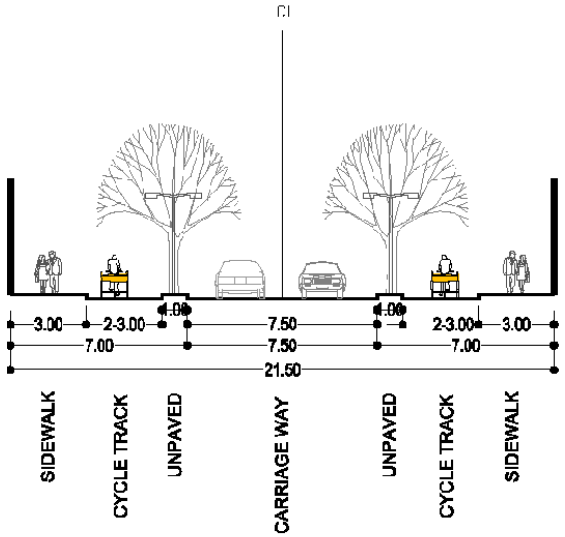
UTTIPEC CROSS SECTION - 30 M ROAD WITH MUZ & METRO

Arterial Road Function

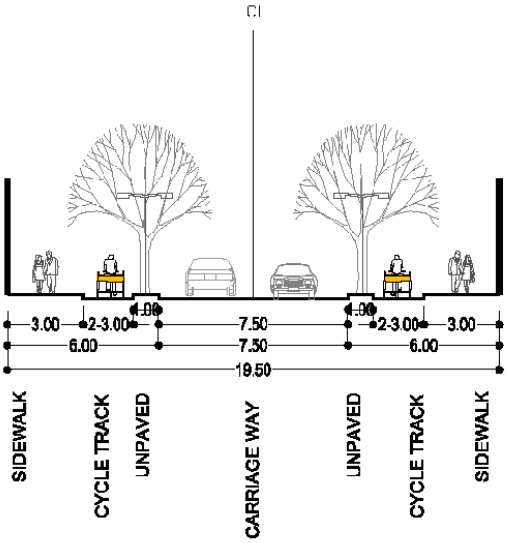


18-24 M Secondary Collector Road

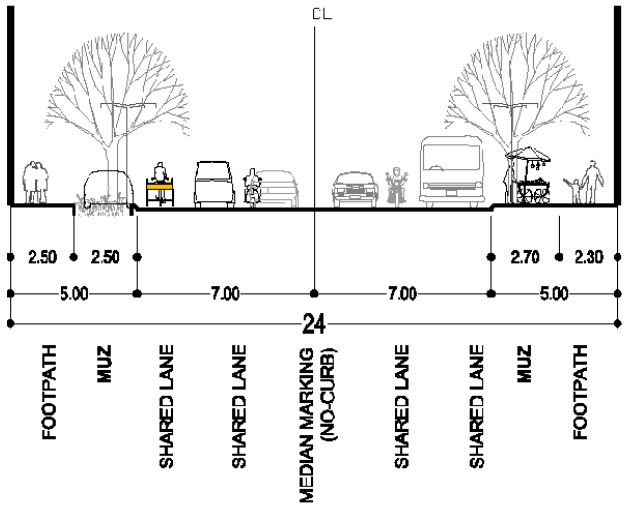
IRC COLLECTOR STREET (2 LANE)



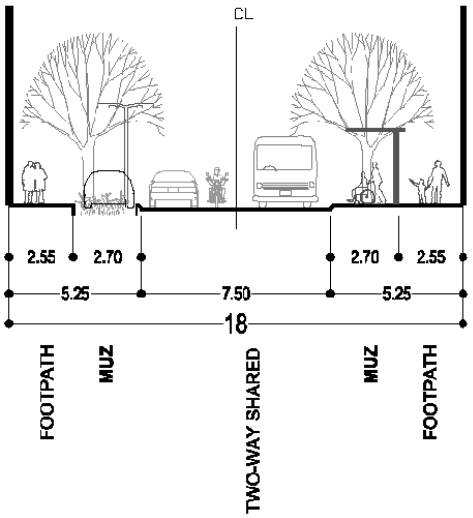
IRC COLLECTOR STREET (2 LANE)



UTTIPEC 24 M ROAD WITH MUZ

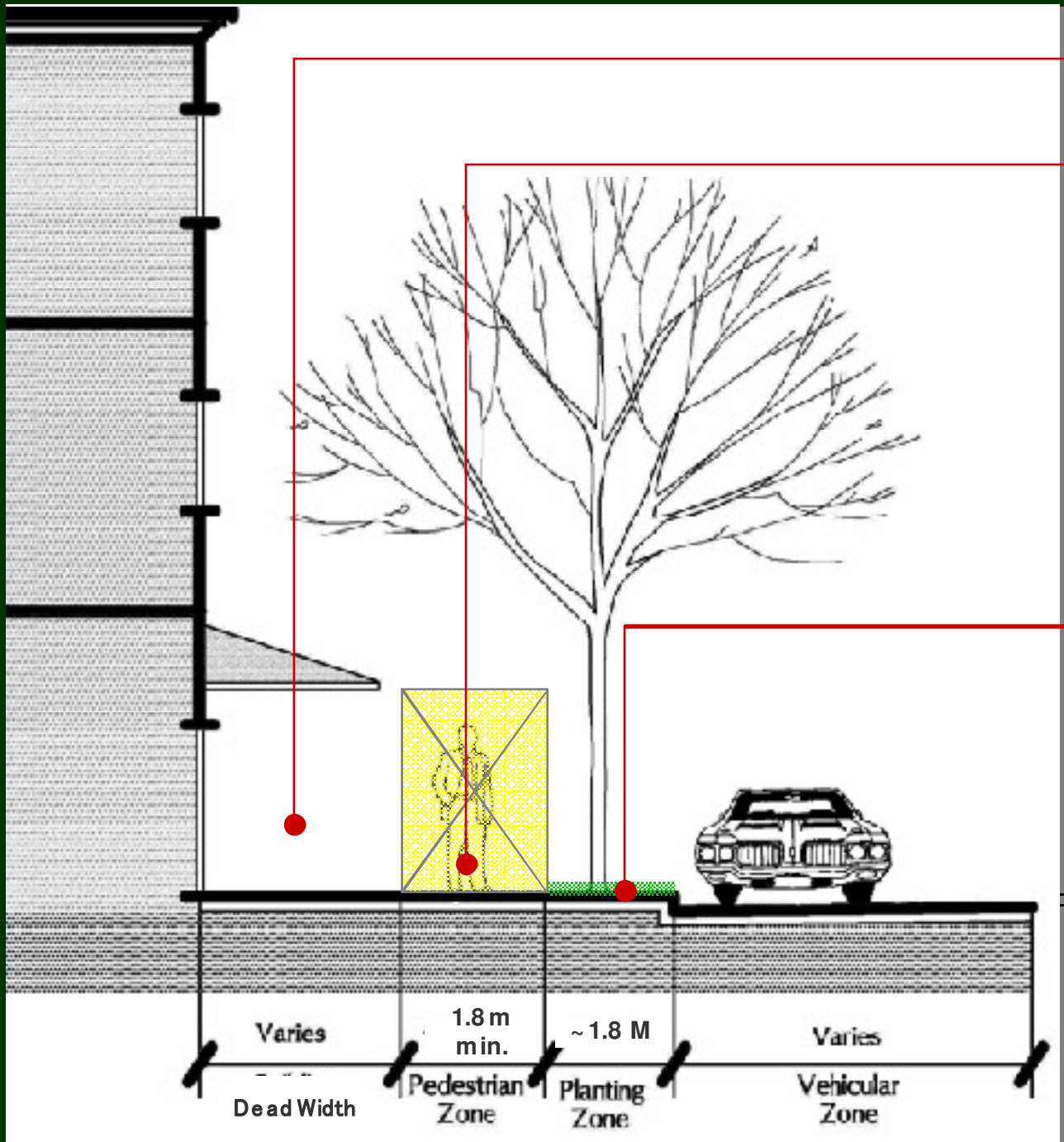


UTTIPEC 18 M ROAD WITH MUZ



5. Design Toolkit:
Mandatory Components

The Three Pavement Zones



02 09

01 03

04 08 09

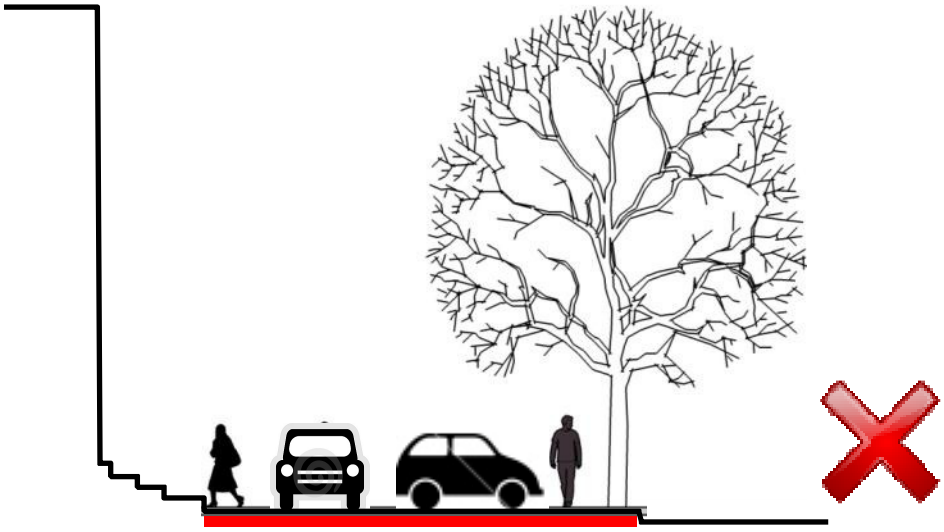
10

*Base Graphic Source: Streetscape Design Guidelines for City of Lancaster Pennsylvania

Not Acceptable

NO clear walkway = Confusion Zone

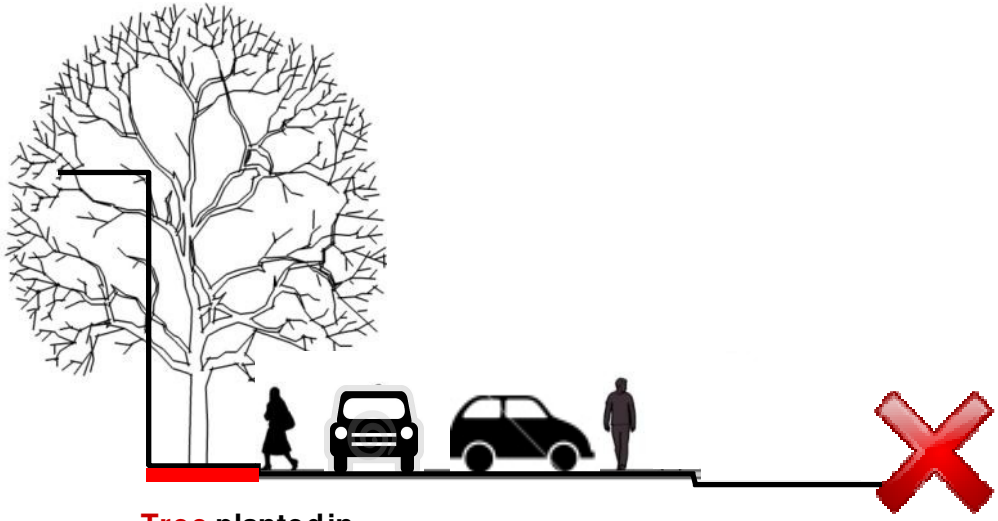
Commercial:



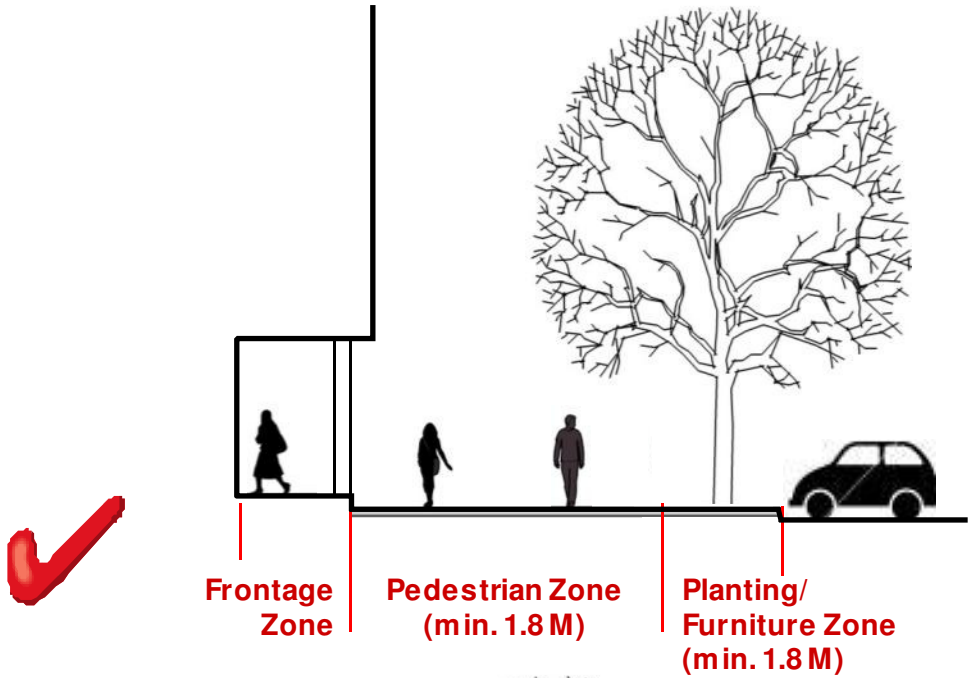
Confusion Zone –
Severe car-pedestrian conflict

Tree branches on walkway

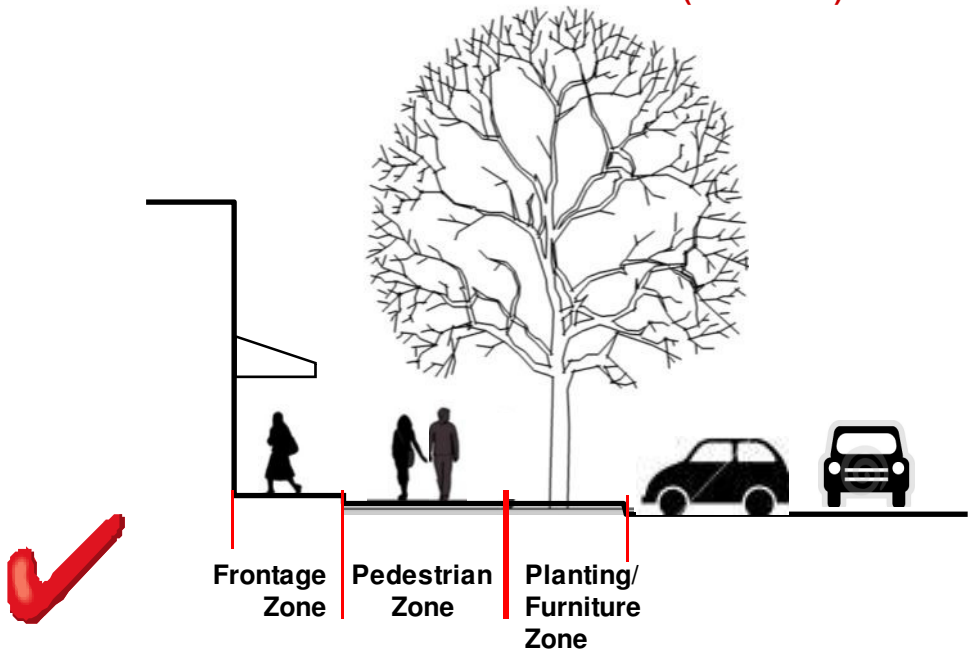
Residential:



Tree planted in walking zone!



Commercial:



Residential:

01 Pedestrian Only Zone

01A Clear Walking Zone

01B Walking Zone Width

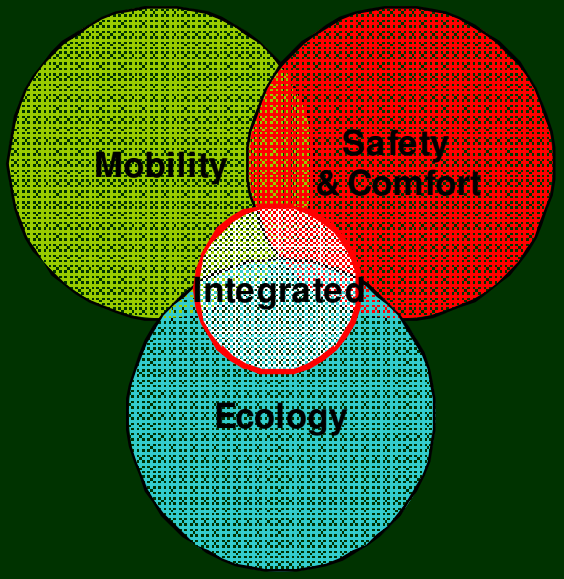
01C Maximum Kerb Height

01D Kerb Radius and Slip Road Treatment

01E Continuous Pavement

01F = See 12 C
High Albedo Materials

01G = See 12D
Permeable Pavement



The Pedestrian Zone is the primary component of every street in a city. It is not only a zone to ensure smooth, comfortable, conflict free movement of pedestrians and public transport users, but also an area which shapes social interactions, safety and quality of life of people in a city.

MAIN PRINCIPLES:

Mobility	- An Obstruction free, safe, comfortable and continuous walking zone must be ensured for pedestrians on all roads of the city.
Ecology:	- Usage of Pervious Paving to build Natural Drainage Systems - Reduce Heat Island Effect by increasing paving reflectivity
Safety/Comfort	- Provide accessibility ramps and tactile paving for the Handicapped - Continuous and uniform walking area - Trees and high-albedo materials to ensure optimal climatic comfort.

Not Preferable

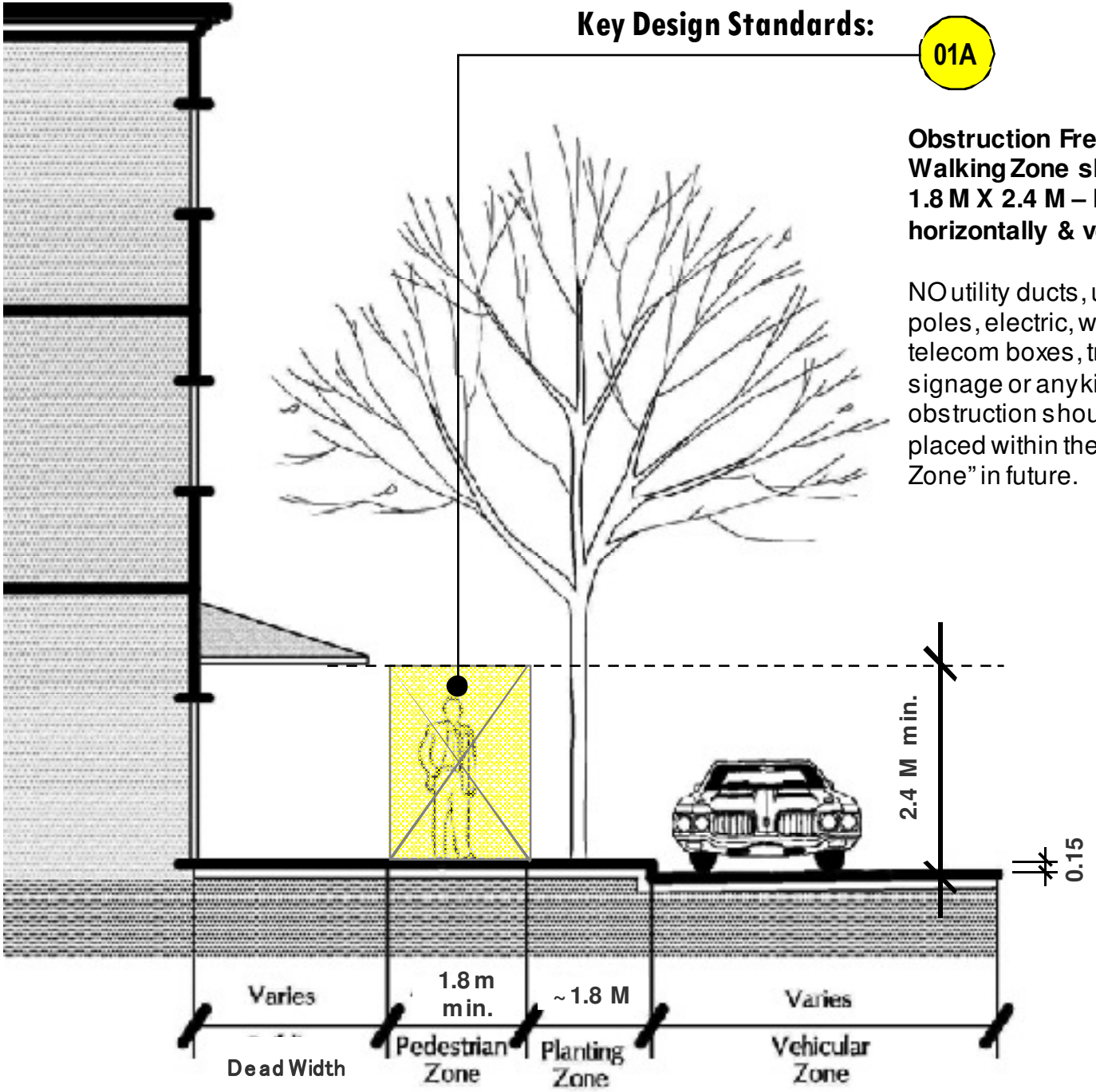
01A Clear Walking Zone

Key Design Standards:

01A

Obstruction Free Min. Walking Zone shall be 1.8 M X 2.4 M – both horizontally & vertically.

NO utility ducts, utility poles, electric, water or telecom boxes, trees, signage or any kind of obstruction should be placed within the "Walking Zone" in future.



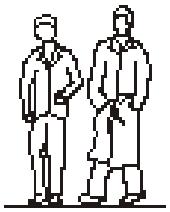
01B - Walking Zone Width

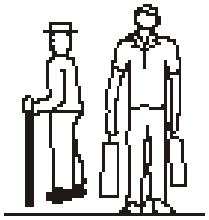
Extra walkway space through tree grates | Effective walkway | Dead Width

Dead Width | Pedestrian Zone | Planting/ Furniture Zone

1.5 M

Not enough





01B **Minimum Walking Zone Width = 1.8 M or More**

Minimum width for two people to cross each other comfortably

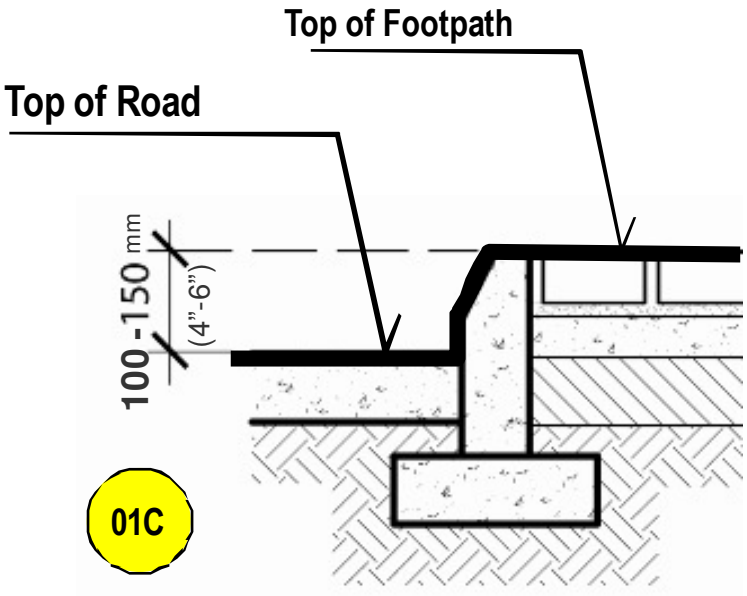
Since the pedestrian flow is determined by land use, the following sidewalk widths can be applied:

Residential Areas:	1.80 M (minimum)
Commercial/Mixed Use Areas:	2.50 M
Commercial Nodes:	4.00 M

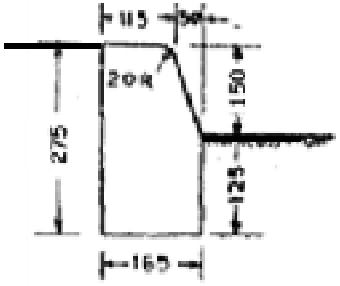
In addition to the above, a requisite "dead width" is to be added to all pedestrian zones, as per IRC Standards in Section 02.

*Note: The term "Curb" may also be considered as an alternate name.

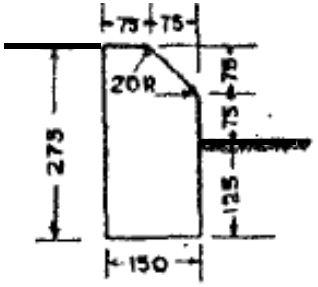
01C - Maximum Kerb* Height



- **Maximum height of a pavement (including kerb, walking surface, top-of-paving) shall not exceed 150 MM (6"). 100 mm (4") kerb height is preferable for Arterial Roads.**
- **All walking surfaces should be very rough/ matt-finish/ anti-skid.**
- **Medians should be maximum 150mm high or be replaced by crash barriers.**
- In case the carriageway finished level is expected to rise during future re-carpeting, reduction in footpath level to 100 mm or less is acceptable. But under no circumstances is the height of footpath to exceed 150 mm.
- **Finished top level and kerb height for all bus-stops to be 150 mm.**
- Only along Segregated Busways/ BRT corridors, the kerb height of the Bus Stop could match the height of the bus floor.



(a) Barrier type



(b) Semi-barrier type

Graphics Source: IRC (modified)

Footpath kerbs should be the following type:

- **Semi-mountable (150 mm high) where traffic volumes are high and efficiency of kerb-side lane is to be maximized. NOTE: In areas where the MUZ is present, the kerb height applies to the edge of MUZ. Footpath height in such cases could range from 0-150mm.**
- **Barrier type (150 mm high) where pedestrian volumes are high and traffic volumes and speeds are less (<25 km/hr) – so as to discourage vehicles from encroaching upon footpath space. The barrier kerb will decrease the efficiency of the left-most traffic lane.**

On roads of design speeds 25-50 km/hr - protection of Pedestrians and NMV, can be ensured by treating the MUZ with fences, hedge-planting or bollards, wherever required. This also helps prevent jay-walking.

On roads of design speeds < 25 km/hr, jay-walking is acceptable so no physical barriers should be installed. Kerbless streets are recommended in heavy pedestrian areas.

Best Practices

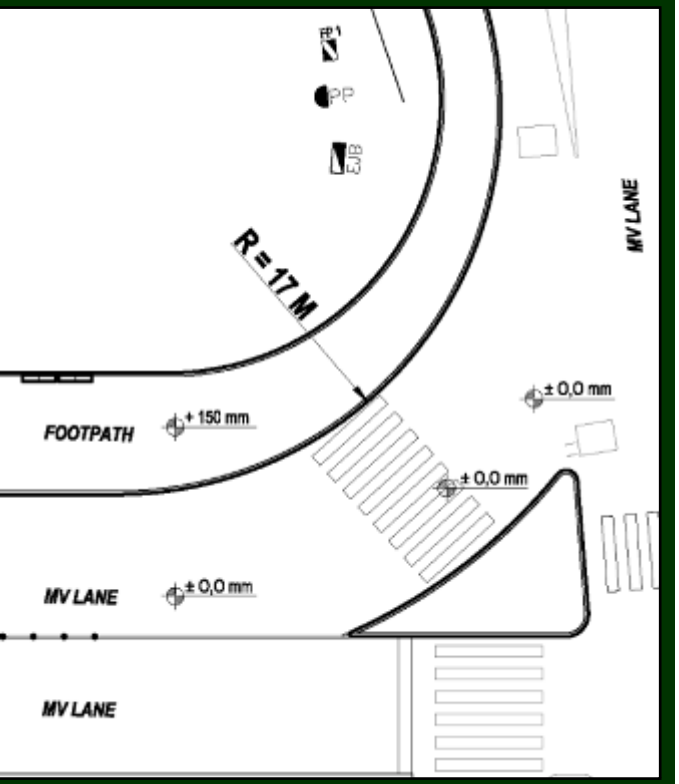
1. **Kerb heights on all roads to be Maximum 150 MM. On Arterial Roads, 100 MM is preferable.**
2. **In case of arterial roads where safety of pedestrians and cyclists is high-priority, the MUZ can be treated with hedge-planting or fencing or bollards, wherever required, to prevent jay-walking. Such barriers would also prevent motorized vehicles from encroaching upon footpaths and cycle tracks.**

The above recommendations were approved by the Governing Body of UTTIPEC on the meeting dated 04.03.2011. Minutes are available on the UTTIPEC Website.

*Note: The term "Curb" may also be considered as an alternate name.

Not Preferable

Non-Signalized Slip Roads i.e. "Free Left Turns" have made navigating the city a nightmare for pedestrians and cyclists.



A Typical Slip road encourages speedy left turns and eliminates safety for pedestrians.

01D Kerb Radius and Slip Road Treatment

Corner Kerb Radii

Smaller turning radii increase pedestrian safety by shortening crossing distances, increasing pedestrian visibility for drivers, decreasing vehicle turning speed; and making drivers look out for pedestrians while taking the turn.

Essential Guidelines:

- **Maximum corner radius of Kerb = 12 M**
- **It may be reduced to 6 M in residential areas to slow down turning buses, trucks etc. with the provision of a corner mountable kerb for emergency vehicles.**

type of vehicle	length (m)	width (m)	height (m)	turning circle radius (m)
motorcycle	2.20	0.70	1.00[2]	1.00
car				
- standard	4.70	1.75	1.50	5.75
- small	3.60	1.60	1.50	5.00
- large	5.00	1.90	1.50	6.00
truck				
- standard	6.00	2.10	2.20[1]	6.10
- 7.5t	7.00	2.50	2.40[1]	7.00
- 16 t	8.00	2.50	3.00[1]	8.00
- 22t (+16 t trailer)	10.00	2.50	3.00[1]	9.30
refuse collection vehicle				
- standard 2-axle vehicle (4 × 2)	7.64	2.50	3.30[1]	7.80
- standard 3-axle vehicle (6 × 2 or 6 × 4)	1.45	2.50	3.30[1]	9.25
fire engine	6.80	2.50	2.80[1]	9.25
furniture van (with trailer)	9.50 (18.00)	2.50	2.80[1]	9.25
standard bus I	11.00	2.50[3]	2.95	10.25
standard bus II	11.40	2.50[3]	3.05	11.00
standard vehicle - bus	11.00	2.50[3]	2.95	11.20
standard vehicle - articulated bus	17.26	2.50[3]	4.00	10.50–11.25
standard articulated truck	18.00	2.50[4]	4.00	12.00[5]
tractor		2.50[4]	4.00	
trailer		2.50[4]	4.00	
max. values of the road regulations				
2-axle vehicle (4 × 2)	12.00	2.50[4]	4.00	12.00
vehicle with more than 2 axles	12.00	2.50[4]	4.00	12.00
tractor with semi-trailer	15.00	2.50[4]	4.00	12.00
articulated bus	18.00	2.50[4]	4.00	12.00
trucks with trailer	18.00	2.50[4]	4.00	12.00

notes:
[1] height of driver's cab; [2] total height with driver, about 2m; [3] with wing mirrors, 2.95m; [4] without wing mirrors; [5] turning circle radius adjusted up to max. as per regulations

Slip Roads

Slip roads on Delhi roads are meant for the "signal free" movement of traffic, and to spare the left turning traffic from having to wait at traffic lights for taking a turn.

While such car-oriented design features has not really helped reduce congestion on city roads, this design feature makes **"crossing the street safely" for pedestrians, cyclists, aged and physically challenged people an impossible task.**

Making street-crossing unsafe for these road users further discourages walking and use of public transport, and therefore induces people to use private vehicles.

Therefore, from a pedestrian and cyclist safety standpoint, Slip roads are undesirable.

**Source: San Francisco Better Streets Plan – Policies and Guidelines for the Pedestrian Realm, June 2008*

Street Kerb Corners and Slip Roads: Recommendations

Slip roads or Free Left Turns should be avoided. For intersections of R/Ws of 30m-30m or lesser, Slip Roads should be removed/ not considered. In cases where they already exist for intersections for intersection of 30m-45m and higher R/Ws, the following Strategies *may* be employed:

Option 1: **Slip Road can be removed wherever Pedestrian and NMV volumes are high (01D-i).**

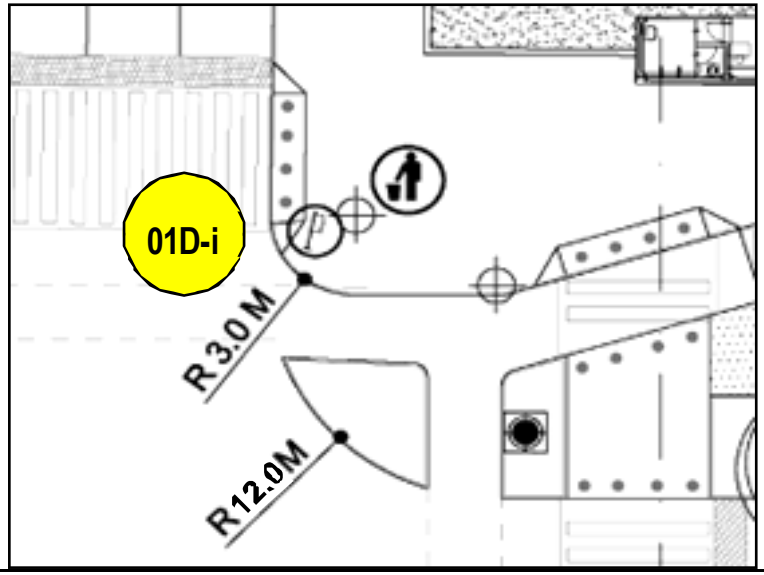
Option 2: **Reduce Corner Radius of kerb to calm traffic (01D-iii), and signalize the Slip road crossing** (full or pelican signal), in order to make them safe for all users.

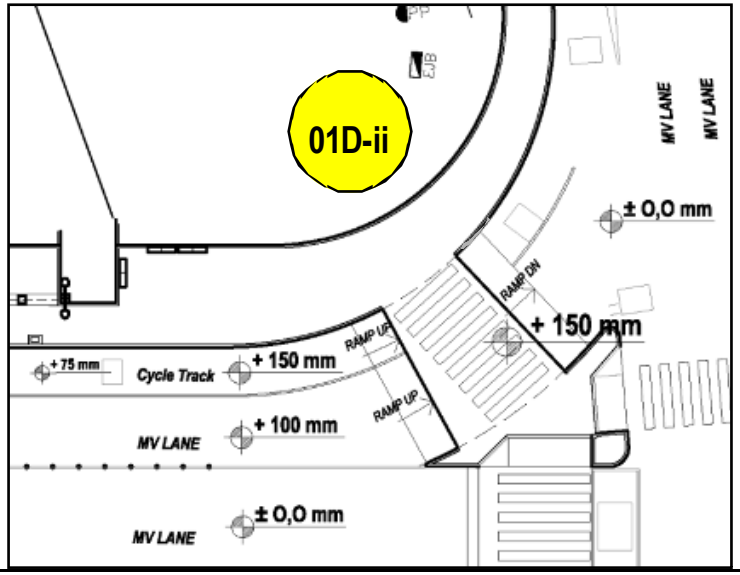
Option 3: **Introduce raised table top crossings at slip roads** and minimum 20-second pedestrians signals **(01D-ii)** – to allow pedestrians, cyclists and physically challenged people to cross the road comfortably at the same level.

Option 4: **Signalized Turning Pockets (01D-iv)** may be provided where left-turning volumes are high.

NOTE: For redevelopment of junctions of road intersections of 30-30m or 30m and above, the issue MUST be brought for discussion with all stakeholders at UTTIPEC before decision.

For intersections of roads 30m and less, Slip roads must be removed, corner kerb radii minimized and pedestrians/ full signals installed - to make the junctions safer.





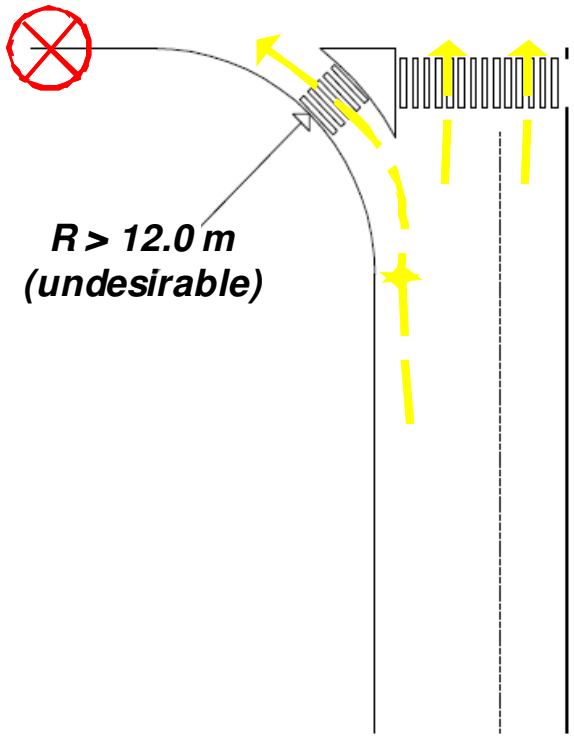
Signalized Slip Road Pedestrian Crossing

Table Top Treatment at Slip Road, ITO Crossing

Not Preferable

01D Kerb Radius and Slip Road Treatment

Best Practices



Current: Typical Delhi Road Intersection

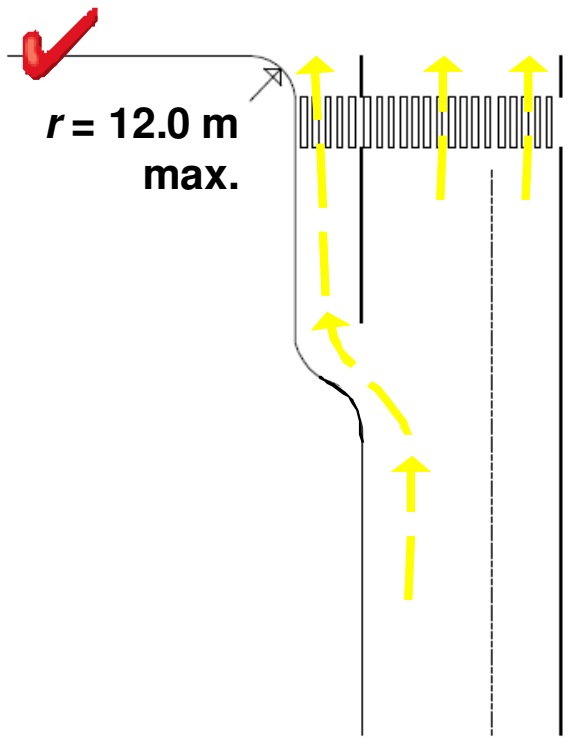
Free left turns/ Signal-free slip roads make traffic turn corners at high speeds, making it unsafe for pedestrians and cyclists to cross.

Free left turns/ Signal-free slip roads have large turning radii which allows traffic to turn at high speeds and provide less visibility making it unsafe for pedestrians and cyclists to cross.

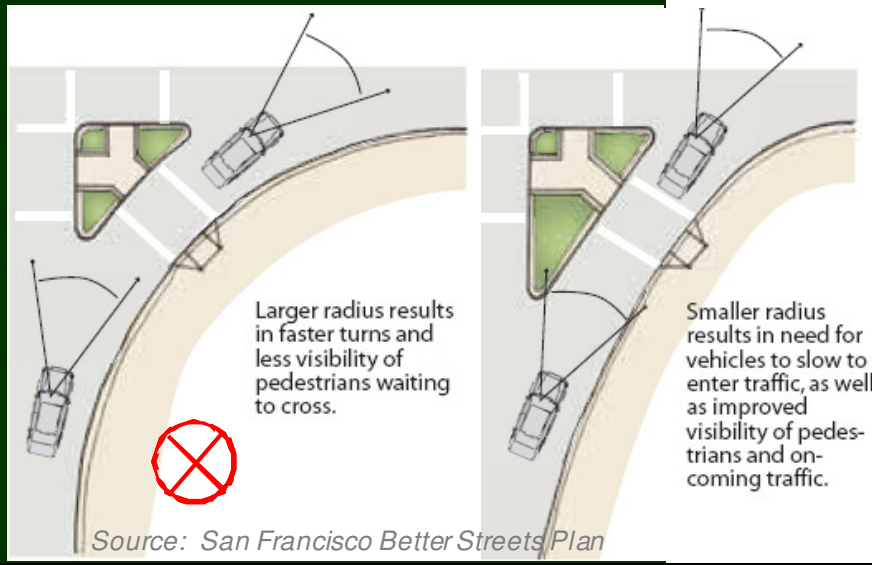
Slip roads may be replaced by Signalized "Left turning pockets" with much smaller corner kerb radii – that ensure Safe, Signalized Pedestrian crossings at junctions.

01D-iii

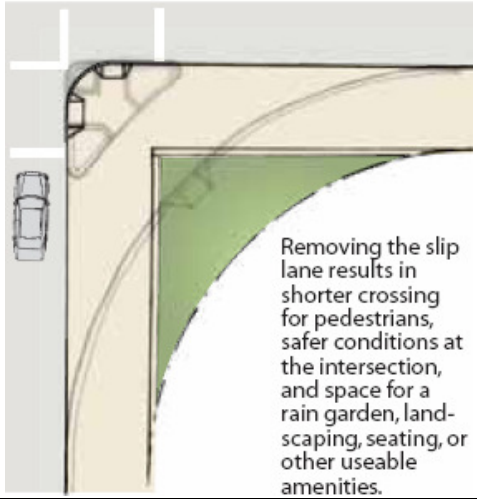
The maximum turning radius "r" allowed in the modified intersection design is 12 m; with recommended 3.0m for most intersections, especially for R/W less than 30m.

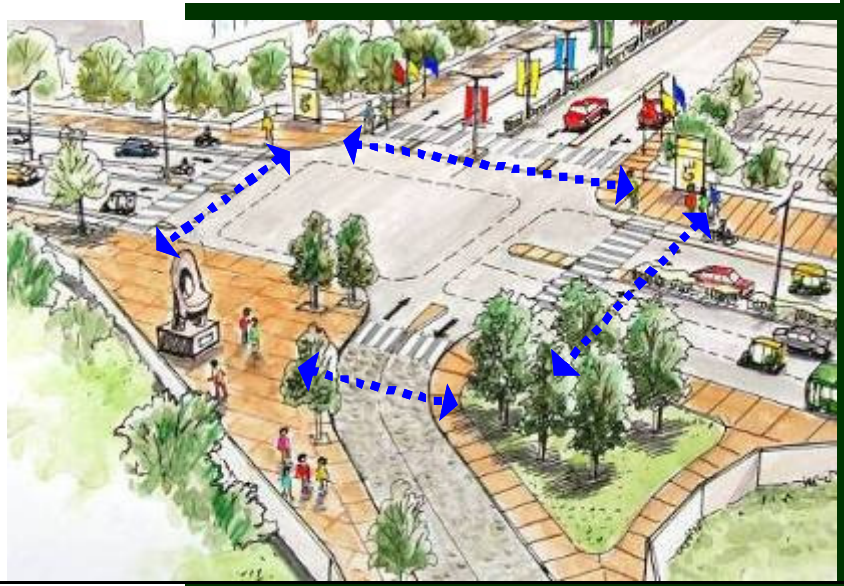


Proposed: Modified Intersection Design



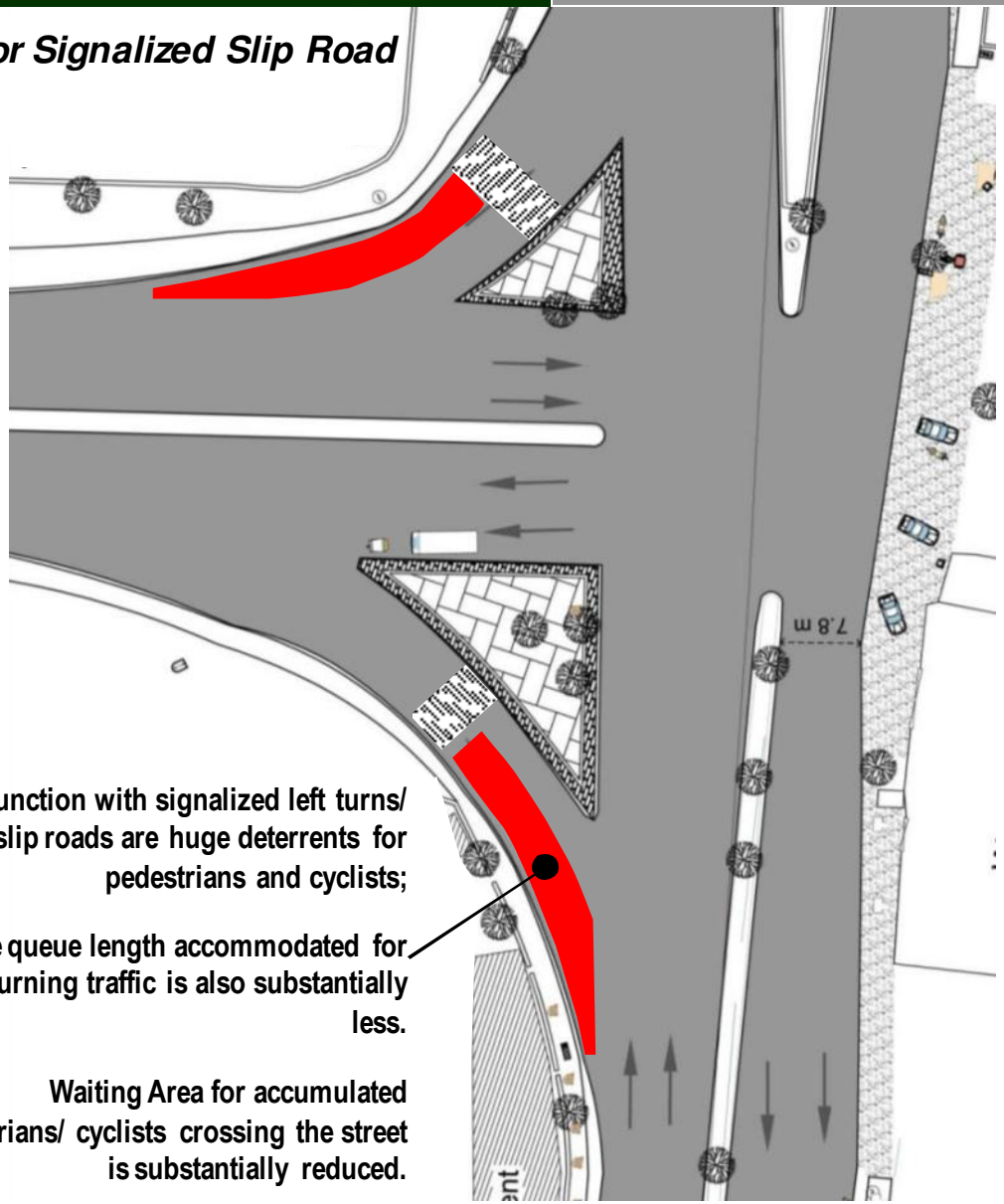
Source: San Francisco Better Streets Plan





Drawings Courtesy: PSDA, 2009

Free or Signalized Slip Road



Road junction with signalized left turns/ slip roads are huge deterrents for pedestrians and cyclists;

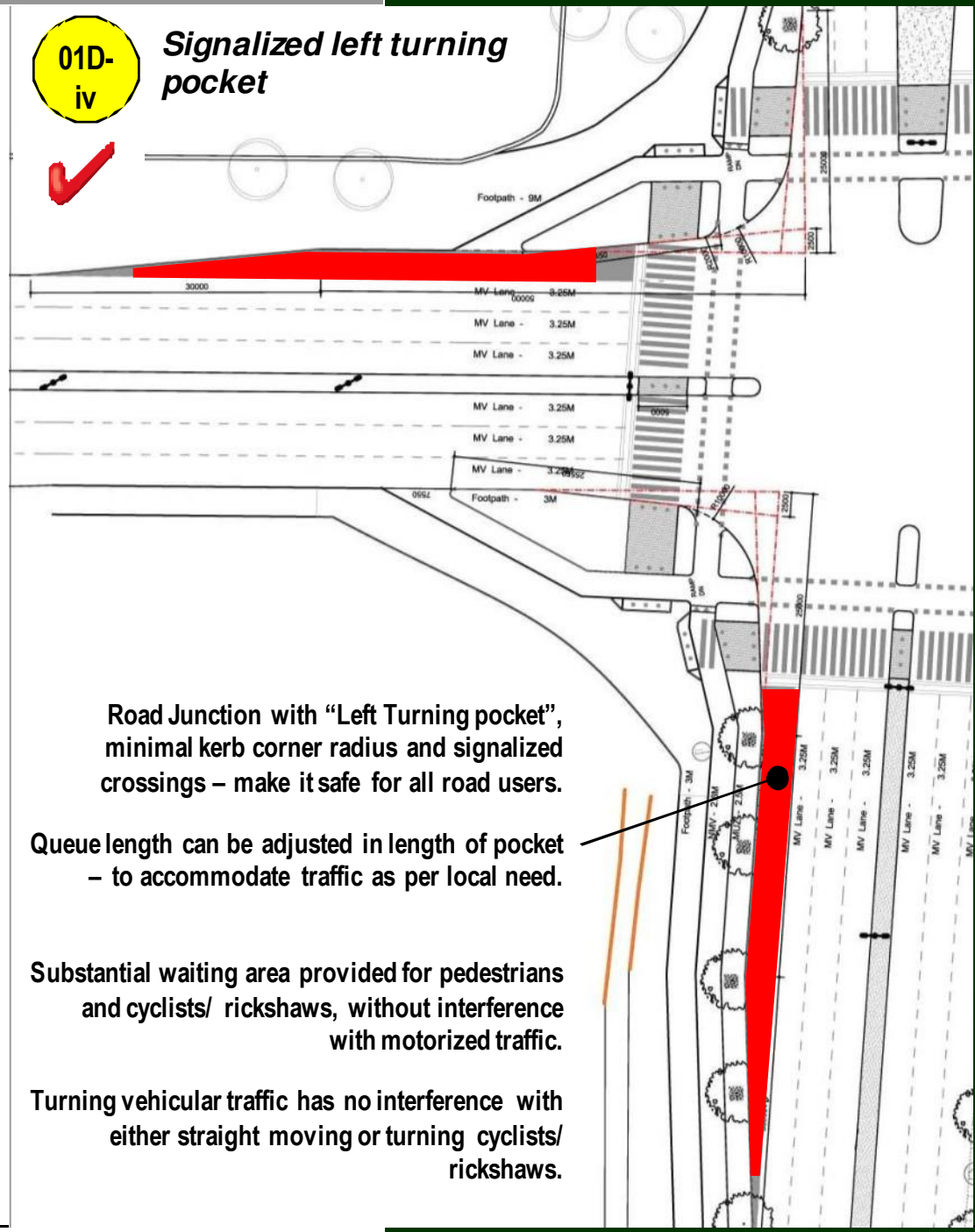
The queue length accommodated for left-turning traffic is also substantially less.

Waiting Area for accumulated pedestrians/ cyclists crossing the street is substantially reduced.

Turning traffic crates major obstruction and danger for straight moving cyclists/ rickshaws.

01D-iv

Signalized left turning pocket



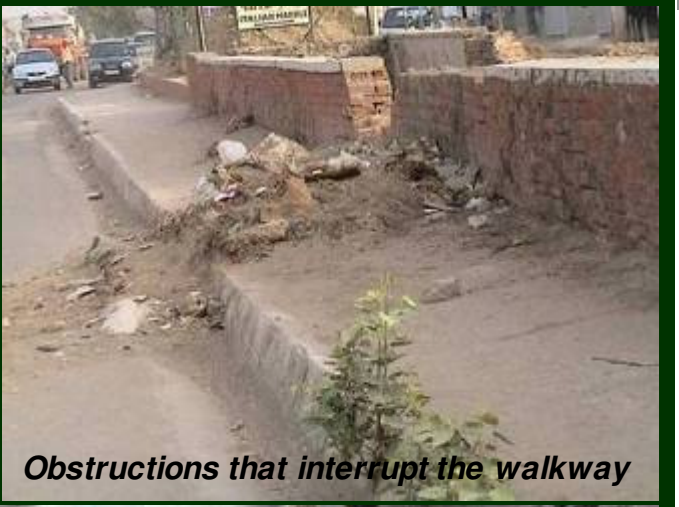
Road Junction with "Left Turning pocket", minimal kerb corner radius and signalized crossings – make it safe for all road users.

Queue length can be adjusted in length of pocket – to accommodate traffic as per local need.

Substantial waiting area provided for pedestrians and cyclists/ rickshaws, without interference with motorized traffic.

Turning vehicular traffic has no interference with either straight moving or turning cyclists/ rickshaws.

Not Preferable



Obstructions that interrupt the walkway

Uneven pavement surface due to lack of proper setting in a concrete sub-base.

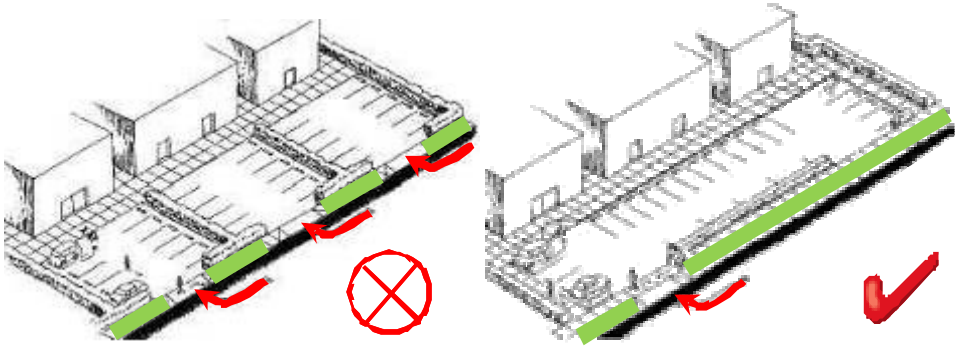
Dramatic changes of elevation

01E Continuous Pavement

Sidewalks and Cycle Lanes should be regarded as a transportation system which is connected and continuous, just like roadways and railways.

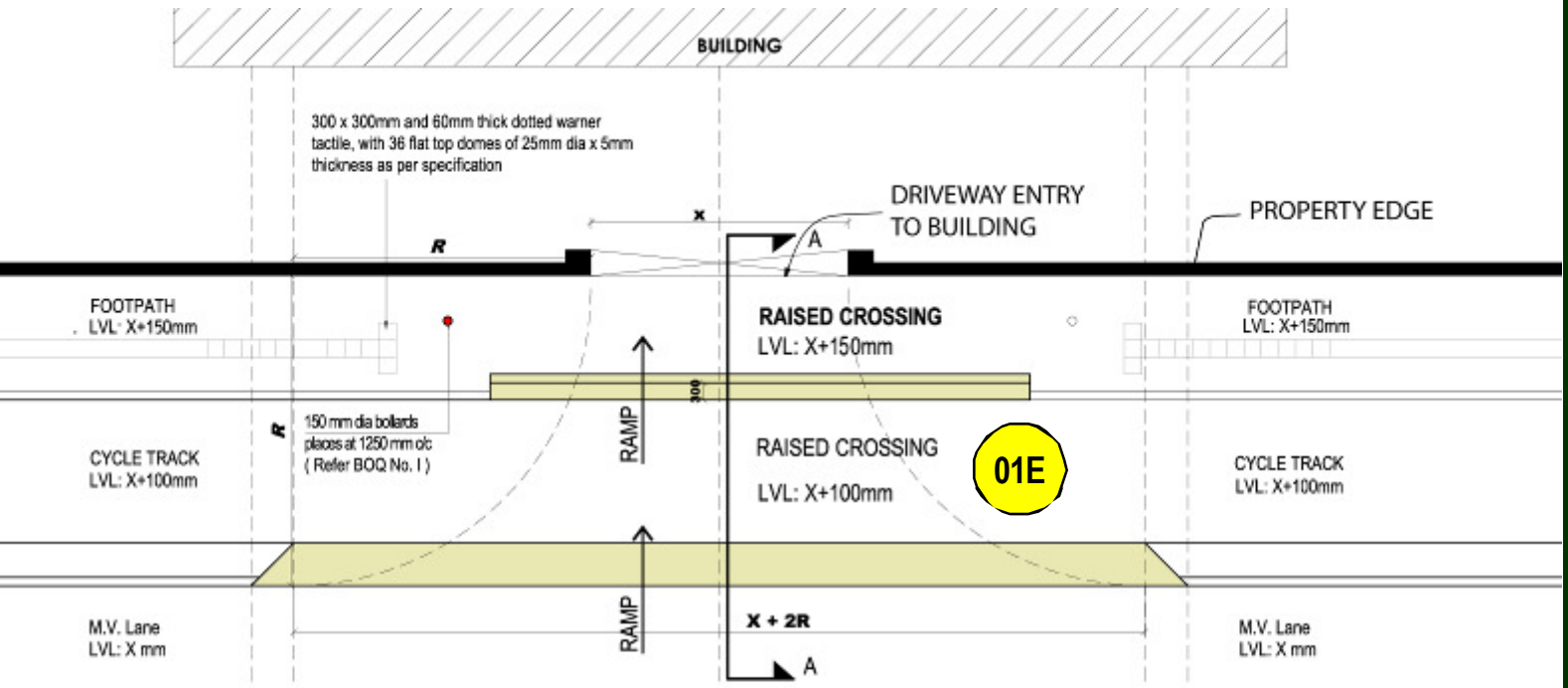
Key Design Guidelines:

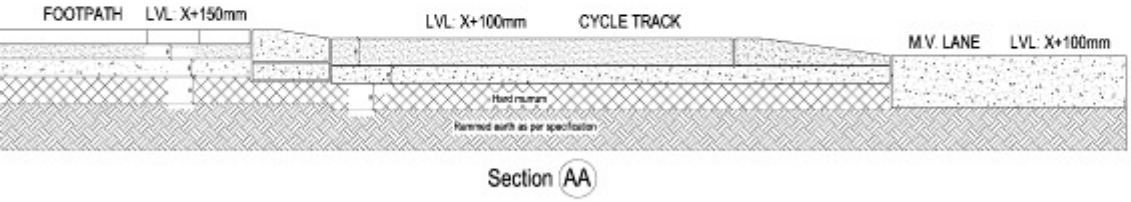
- Avoid sidewalk interruptions by **minimizing kerb cuts** i.e. Minimize the number of driveways that cross the sidewalk – in order to support pedestrian safety and a continuous sidewalk.
- Maintain an **even surface and elevation** of the pavement at 150 MM or less from surrounding road level.
- At entry points of properties – introduce **"raised driveway" or "table-top" details** – where pedestrian and cycle tracks continue at their same level, but the motorized vehicles have to move over a gentle ramp to enter the property.
- Remove all obstructions from the sidewalks.
- **Consistency of design elements, color and texture, help provide visual continuity and calm traffic, even at crossings.**



Source: FHWA Course on Bicycle and Pedestrian Transportation,, 2006

01E At entry points of properties – introduce "raised driveway" or "table-top" details – where pedestrian and cycle tracks continue at their same level, but the motorized vehicles have to move over a gentle ramp to enter the property.





R= The perpendicular distance between Compound Wall & MV Lane edge.
x = width of the Gate or Road.
if R ≤ 6M then
WIDTH of Raised Crossing= x + 2R
if R > 6M then
WIDTH of Raised Crossing= x+(2X6)=x+12

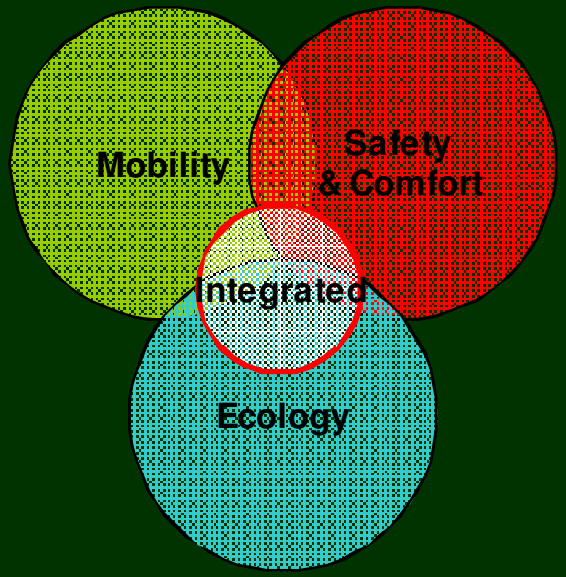
R= The perpendicular distance between Compound Wall & MV Lane Unpaved.
x= 4.50M
R= 5.20M
WIDTH of Raised Crossing= x+2R
=4.50 + 2 X 5.20= **14.90M**

Typical Detail of Raised Driveway at Building Entries.

Source: TRIPP, IIT Delhi, BRT Design Specifications, 2009

BRT Corridor, New Delhi

02 'Dead Width'* or Frontage Zone



- Attractive windows and hawkers in shopping districts, or entries and steps leading up to buildings - create momentary stoppages of curious pedestrians or users of the buildings.

  This is a desired element of a successful and active street.

- These window watchers take up about 0.5 to 1.0 m of additional space, which must be provided in order to ensure conflict free movement of all pedestrians.

*Source: IRC: 103 - 1988

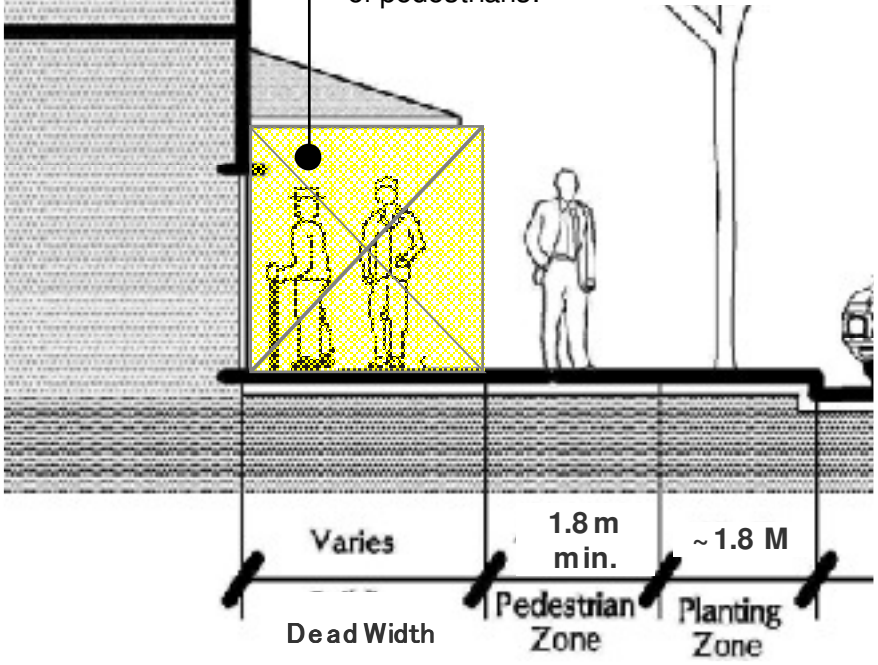
Not Preferable

Above: No extra space allowed for pedestrians interested in stopping at attractions. Therefore stopping pedestrian disrupts moving pedestrian flow on sidewalk.

02 Dead Width

Key Design Standards*: 02

- **For sidewalks in shopping areas, an extra 1M should be added to the stipulated 4.00 M width.** This extra width is called "Dead Width".
- In other situations where sidewalks pass next to buildings and fences, a **dead width of 0.5 M can be added.**
- In busy areas like bus stops, railway stations, recreational areas, the width of sidewalk should be suitably increased to account for accumulation of pedestrians.



*Source: IRC: 103 - 1988

Best Practices

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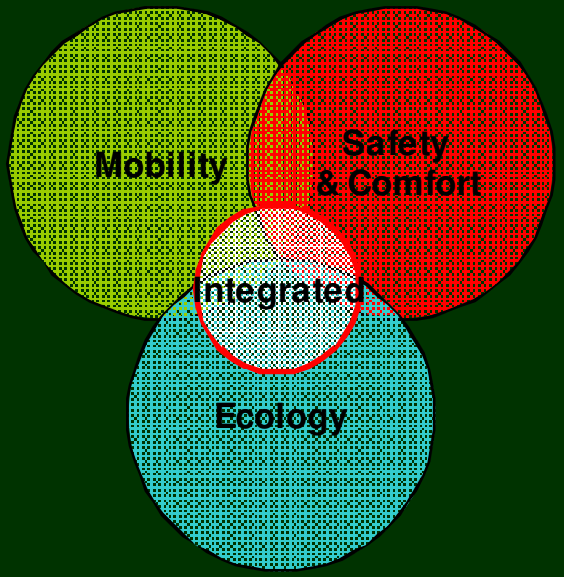
03 Universal Accessibility

- 03A Kerb Ramps
- 03B Raised Table-Top Crossings
- 03C Tactile Paving
- 03D Auditory Signals
- 03E Accessible Signage

San Francisco

Photo Source: San Francisco Better Streets Plan



Universal Accessibility is required for all sidewalks, crossings, parks, public spaces and amenities – for people using wheelchairs, strollers, walkers, crutches, handcarts, bicycles, aged people, visually or hearing impaired, and pedestrians with temporary mobility impairment or injury.

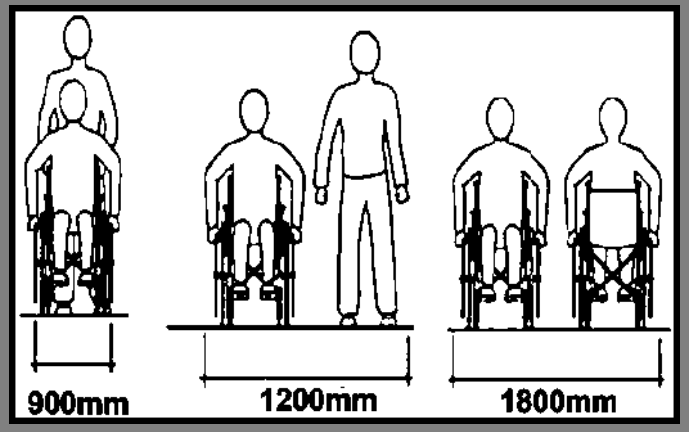
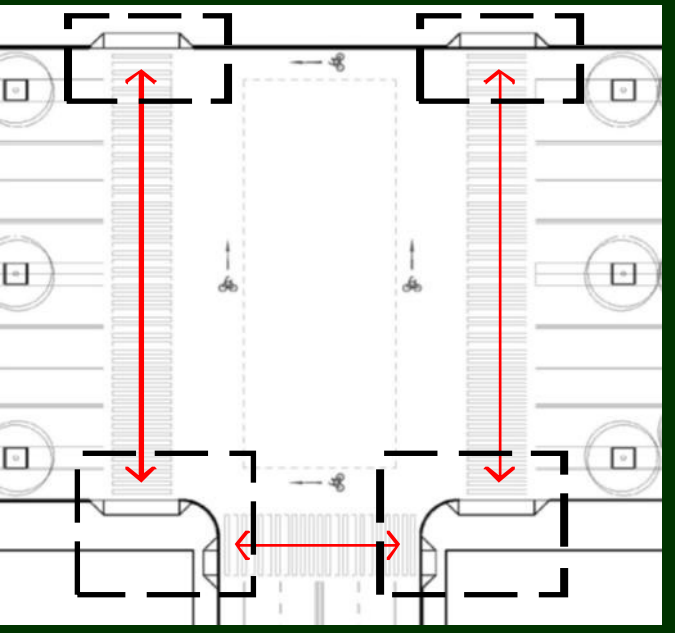


Diagram Source: Samarthyam, National Center for Accessible Environment, Research Report- Road Safety, 2008

03A Kerb Ramps*

Location of Kerb Ramps must align with the Zebra Crossing location and the location of Kerb-ramp on the opposite side.



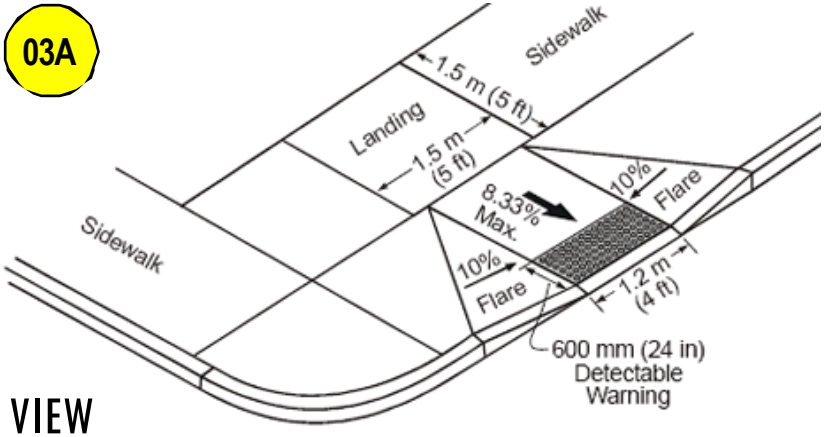
Kerbed Ramp with Tactile Paving

Kerb ramps provide pedestrian access between the sidewalk and roadway for people using wheelchairs, strollers, walkers, crutches, handcarts, bicycles, and pedestrians who have trouble stepping up and down high kerbs. **The absence of kerb ramps prevents any of the above users from crossing streets.**

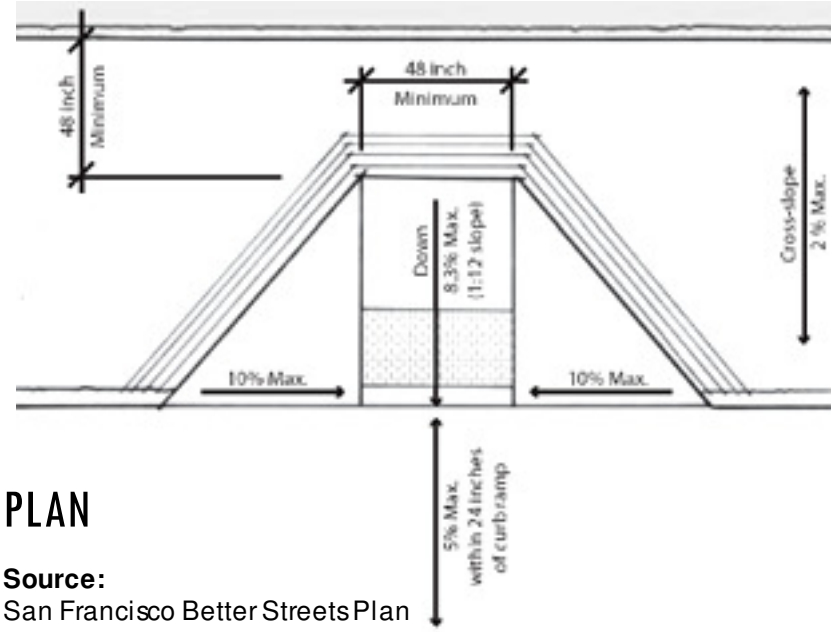
Kerb ramps must be installed at all intersections and mid-block locations where pedestrian crossings exist.

At Signalized Crossings: Use **Kerb Cut- Ramps**

03A



VIEW



PLAN

Source:
San Francisco Better Streets Plan

Key Design Guidelines:

- Standard kerb ramps are cut back into the footpath (flush with roadway), at a gradient no greater than 1:12, with flared sides (1:10) providing transition in three directions.
- Width of the kerb ramp should not be less than 1.2 M.
- Tactile warning strip to be provided on the kerb side edge of the slope, so that persons with vision impairment do not accidentally walk onto the road.
- The ramps should be flared smooth into the street surface and checked periodically to make sure large gaps do not develop between the gutter and street surface.
- It is desirable to provide two kerb cuts per corner. Single ramp located in the center of a corner is less desirable. Separate ramps provide greater information to pedestrians with vision impairment in street crossings.
- Mid block crossings accessible for persons with disability should be provided for blocks longer than 250M.

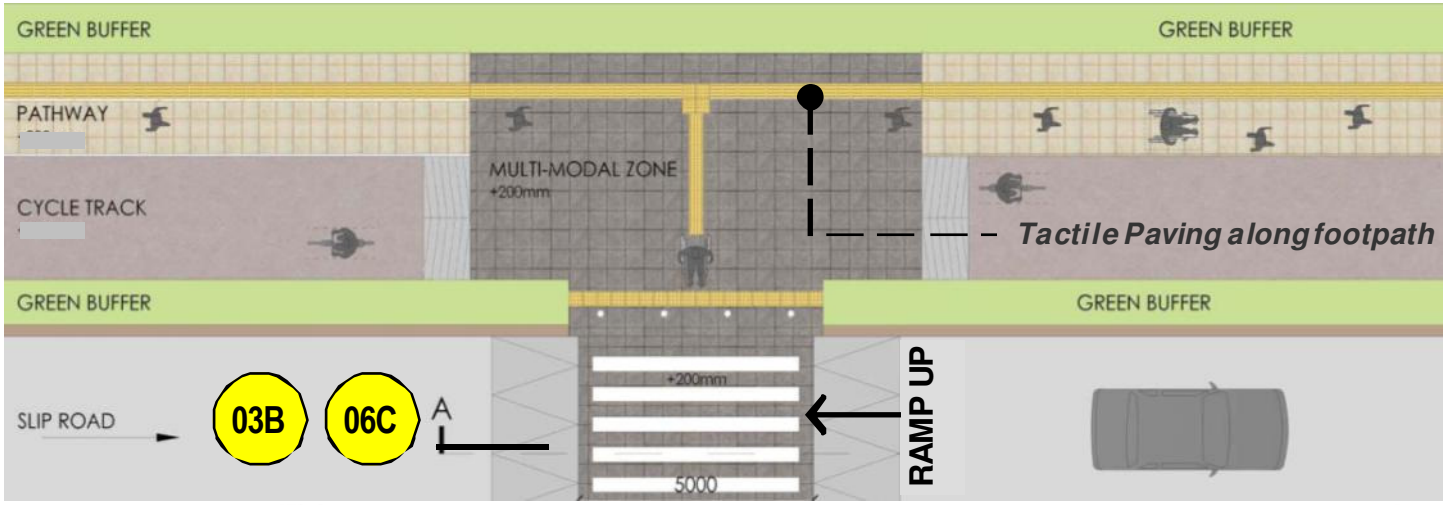
Source: Guidelines for Inclusive Pedestrian Facilities, Report for IRC by Anjlee Agarwal, Samarthyam.org

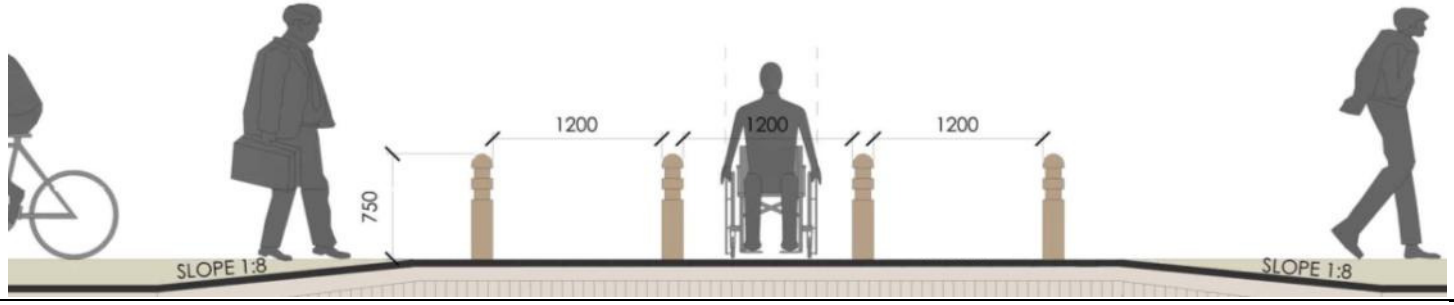
03B Raised "Table-top" Crossing (See also 06B)

At Non-Signalized Crossings: **Use Raised "Table-top" Crossings**

Key Design Guidelines:

- Raised crossings bring the level of the roadway to that of the sidewalk, forcing vehicles to slow before passing over the crossing and enhancing the crossing by providing a level pedestrian path of travel from kerb to kerb. Cobble stone are not recommended on the top, but on the slopes.
- Raised Crossings also increase visibility of pedestrians and physically slow down traffic allowing pedestrians to cross safely.
- **Raised crossings should be located at:**
  - At Slip Roads (free left turns)
  - Where high-volume streets intersect with low-volume streets, such as at alley entrances, neighborhood residential streets, and service lanes of multi-way boulevards.
  - At Mid-Block Crossings





Sample Drawings Courtesy: Oasis Designs Inc.

Best Practices

Table-Top Crossing at Intersection, London

Bollard spacing shown here is too less...

Spacing between Bollards on a Kerb Ramp must be minimum of **900 MM** (3 feet).

Table top crossing at Intersection, Bogotá

03C Tactile Paving (See also 07A)

Tactile paving marking top & bottom of steps.

Accessible Bus Stop, Delhi

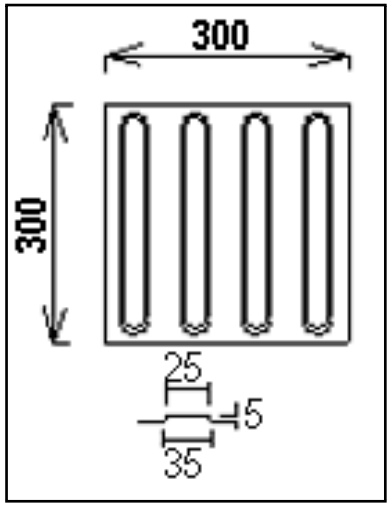
Tactile paving on footpath leading to ramp and crossing, BRT Corridor Delhi

Persons with vision impairment need guidance in using a pedestrianised area, especially if the footway crosses larger open spaces where the usual guidance given by the edge of the footway or building base is not available, or when pedestrians need guidance around obstacles.

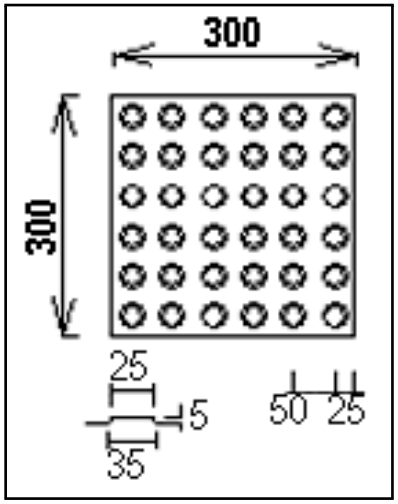
A continuous tactile guide (guiding & warning tile) in the direction of pedestrian travel, which has a different texture to the rest of the footway, can provide this guidance.

Key Design Guidelines:

- A **distance of 600-800mm to be maintained from the edge of footpath**/ boundary wall/ any obstruction.
- A **height of about 5mm** for the raised part of the surface is sufficient for almost all persons with vision impairment to detect, without causing too much discomfort for other pedestrians.
- Tactile paving must be maintained to ensure that the profile does not erode away. **Vitrified non-glazed tactile pavers are preferable.**
- Tactile tiles should have a colour (preferably canary yellow), which contrasts with the surrounding surface.
- Tactile Paving should be **minimum 300mm wide** so that someone can't miss it by stepping over it.



"Go" - Guiding Tile



"Stop" - Warning Tile

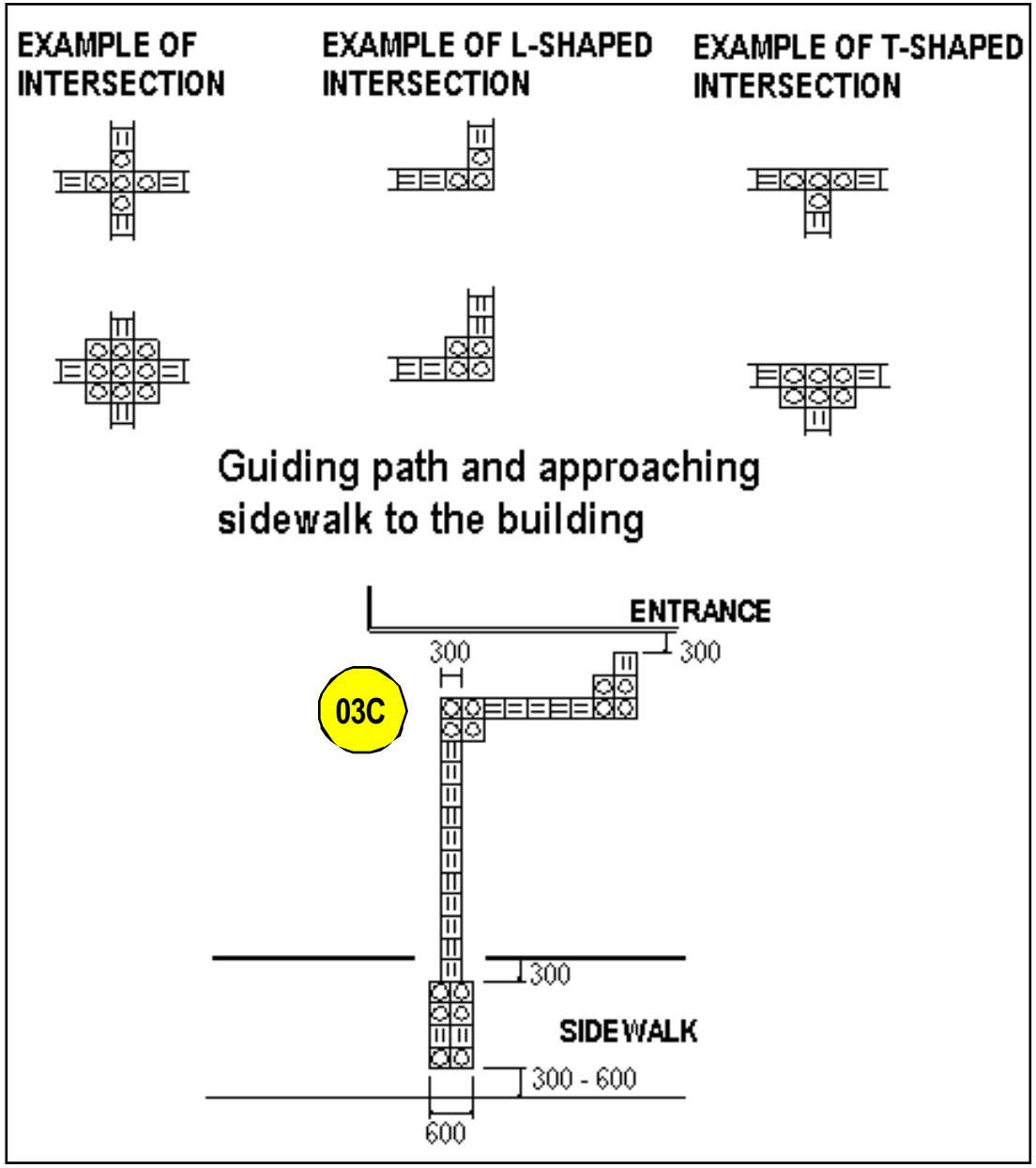
Engineering configuration of floor tactile tiles

Source: Guidelines for Inclusive Pedestrian Facilities, Report for IRC by Anjlee Agarwal, Samarthyam.org

03C Tactile Paving (See also 07A)

Tactile pavers (Guiding and warning path) should be provided:

- To lead persons with vision impairments to the lifts, crossings, toilets, bus stops, i.e. all public and road facilities.
- In front of an area where traffic is present.
- In front of an entrance/exit to a facility like subway/FOB/public utility.
- To and from a staircase or multi-level crossing facility.
- In open space to orient persons with vision impairment.



Source: CPWD Guidelines and Space Standards for Barrier Free Built Environment for Disabled and Elderly Persons 1998, Ministry of Urban Development

Best Practices

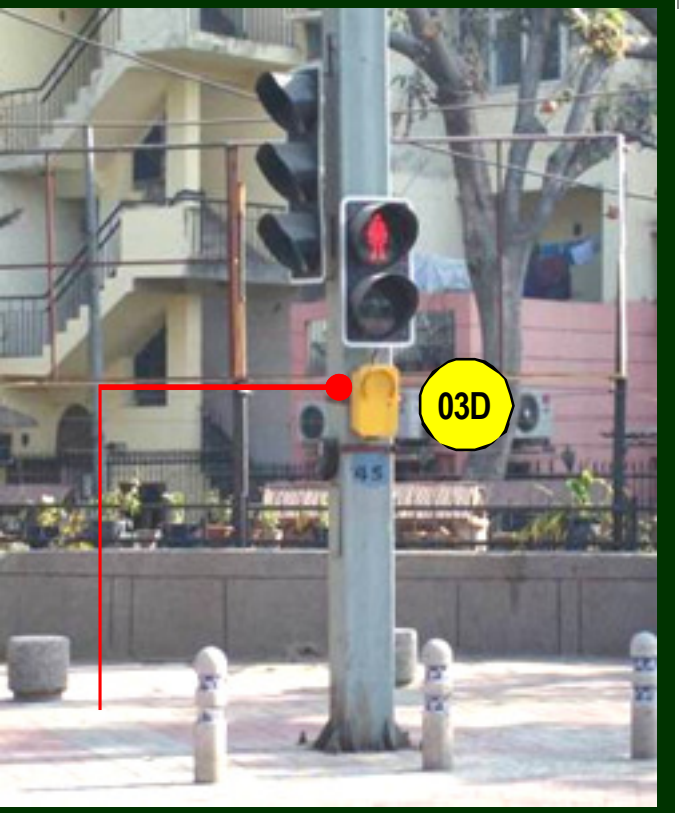
Tactile paving on footpath leading to ramp and crossing: BRT Corridor

Design specifications:

Ramp slope	8% maximum
Gutter slope	5% maximum
Flare slope	10% maximum
Lip at roadway	6mm maximum, flush surface
Ramp width	1200mm minimum, width of crossing
Landing width	1500mm
Cross fall on landing and approach	2% maximum
Width of tactile warning surface	610mm

Source: Guidelines for Inclusive Pedestrian Facilities, Report for IRC by Anjlee Agarwal, Samarthyam.org

03D Auditory Signals

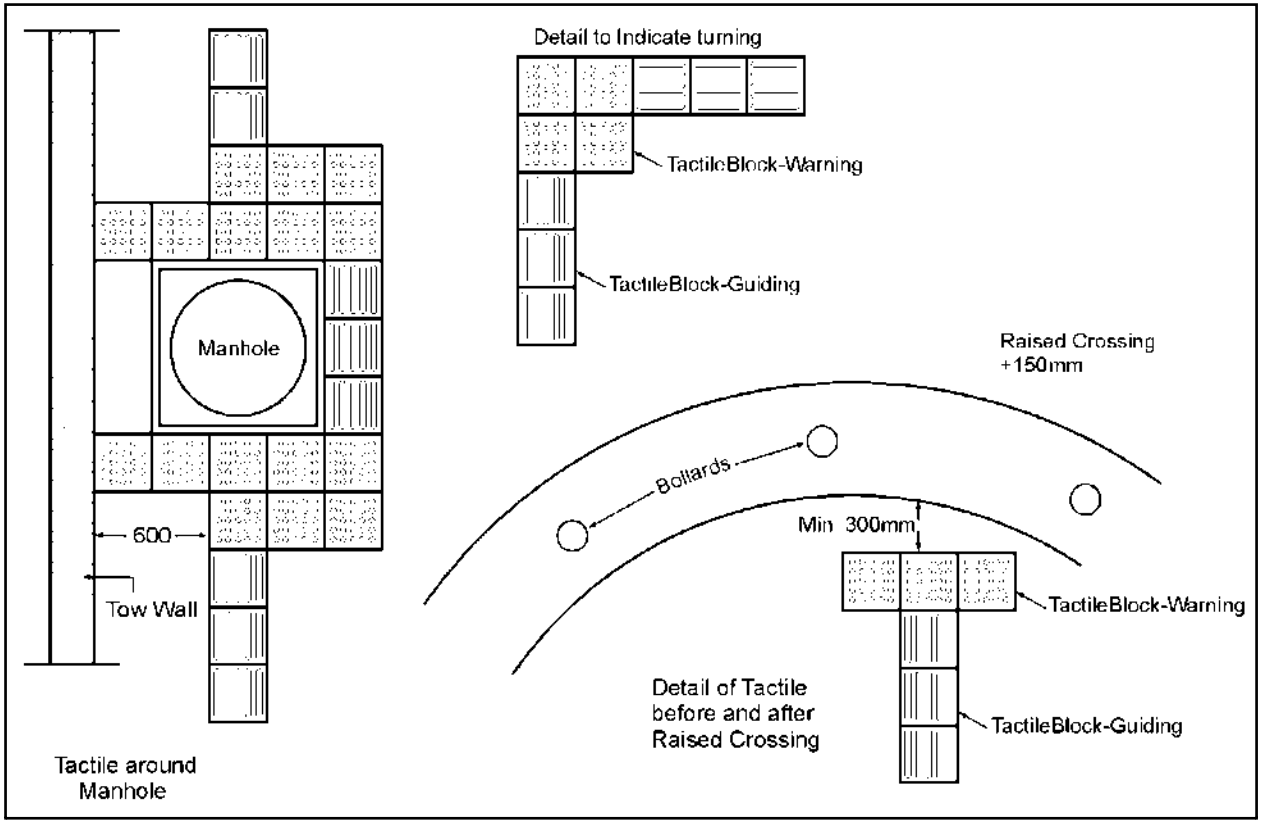


Audible signals which beep when light is green (BRT Corridor, Delhi)

Accessible Bus Stop, Delhi

Key Design Guidelines:

- **Audible crossing signals (pelican crossings)** help everyone, as well as being essential for persons with vision impairments.
  - Pedestrian traffic lights should be provided with clearly audible signals to facilitate safe and independent crossing of pedestrians with low vision and vision impairment.
  - Acoustic devices should be installed on a pole at the point of origin of crossing and not at the point of destination.
- Tactile paving should be provided in the line of travel **avoiding obstructions such as manholes/ tree guards/lamp posts etc.**



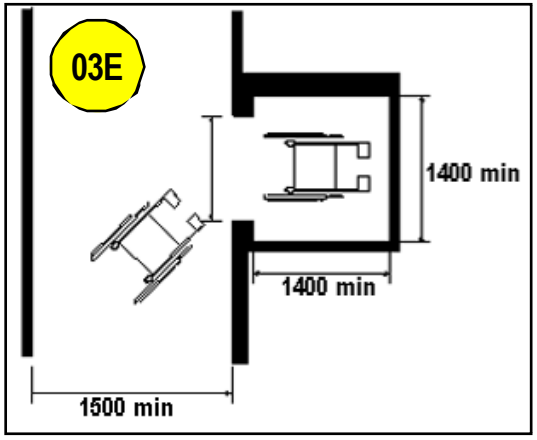
Tactile lay out for manhole and raised crossing

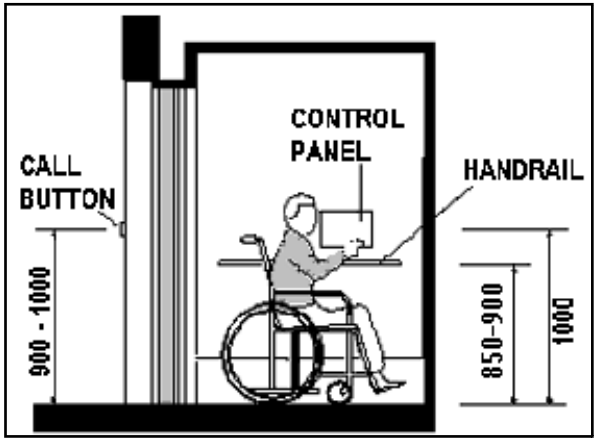
Source: Guidelines for Inclusive Pedestrian Facilities, Report for IRC by Anjlee Agarwal, Samarthyam.org

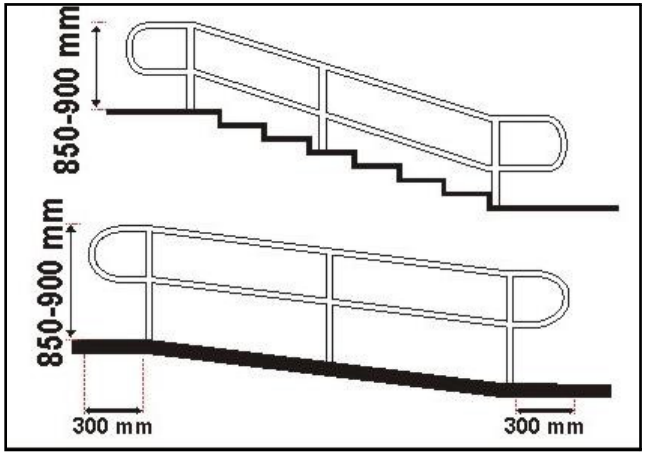
03E Accessible Infrastructure (See also Section 10)

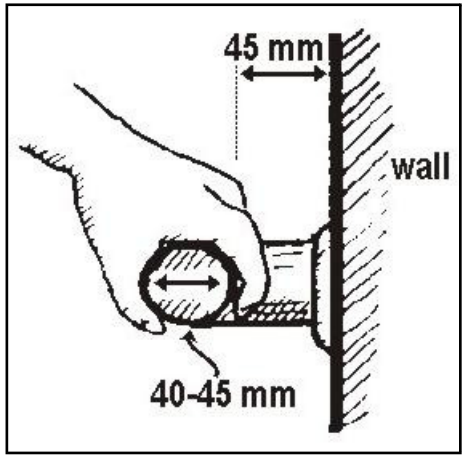
Key Design Guidelines:*

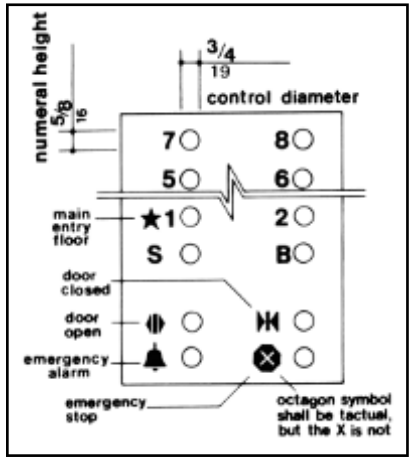
- A slope of 8% (1 in 12) on footbridge ramps, while a slope of 5% (1 in 20) with appropriate resting places/landings is preferable .
- Within the underpass, a handrail set 850mm-900mm (Figure 32 & 33) above the walking surface should be provided.
- To assist visually impaired people, tactile paving/ tiles and a colour contrast should be provided at the top and bottom of the flight of steps and these areas should be well lit.
- Elevator/lift should be provide on both the entrances/exits and should have minimum internal dimensions of 1400mm x 1400mm.
- All Lifts to have Braille buttons and audio announcement systems.





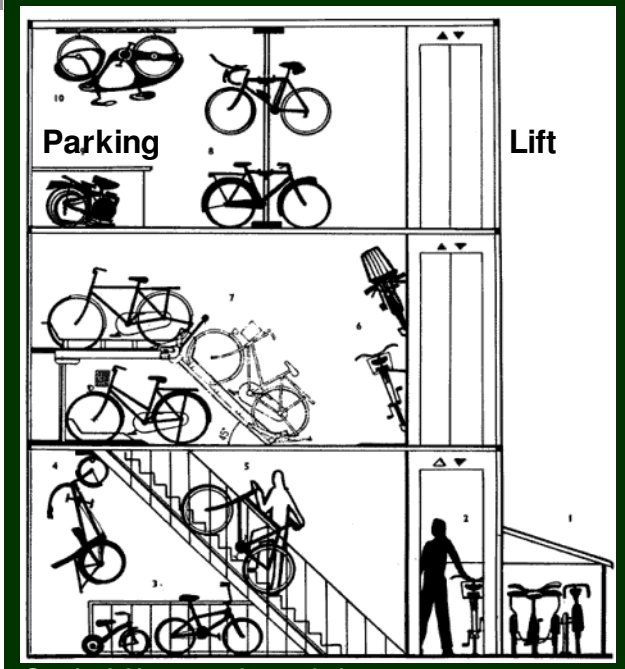






*Source: Access for All, Guidelines for TOT for promotion of Universal Design, 2008, Samarthyam

Best Practices



Cycle Lift must be minimum 2000 x 1400 and provided at every 1 km on a highway FOB, and at all public buildings.

Accessible Crossing Lift, Shanghai

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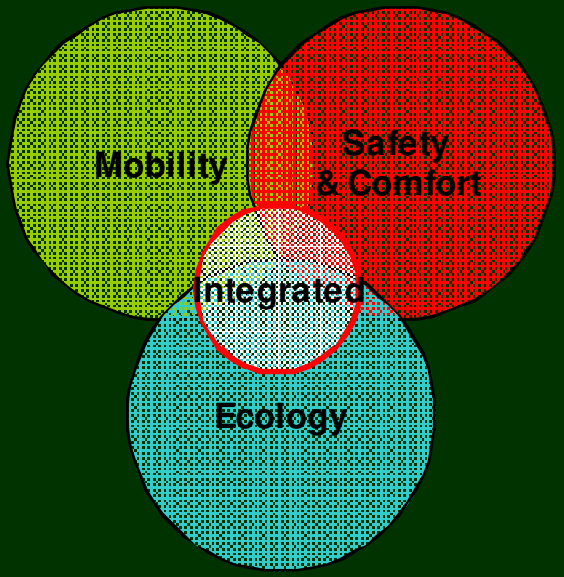
04 Multi-Functional Zone with Planting

04A Essential Planting

04B Tree Pits and Tree Grates

04C Planting with Storm Water Management

04D Aesthetic Planting



Multifunctional Planting zones with native Street Trees and Plantation – are Essential on every Delhi pavement to provide shade and climatic comfort. Planting zones can also double as Natural Storm Water catchments and filtration systems - aiding in ground water recharge, preventing seasonal flooding and reducing the pressure on piped stormwater infrastructure.

MAIN PRINCIPLES:

Mobility - Avenue tree plantation is a must on all streets of Delhi in order to provide shade and comfort to pedestrians.

Ecology: - Integrated Natural Drainage Systems
- Native plantation for resistance and water conservation.

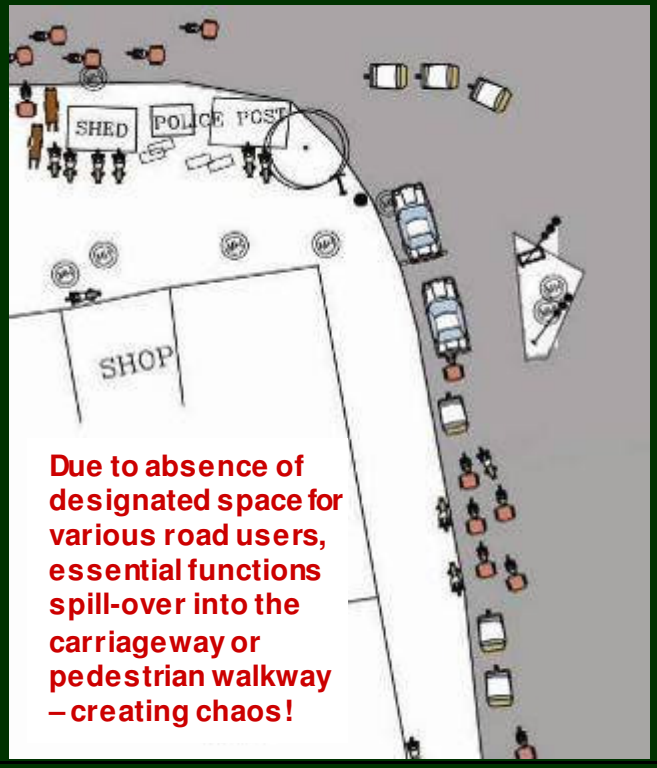
Safety/Comfort - Tree planting zones with native street trees and plantation – are essential for shade, lowering HIE and giving comfort to pedestrians.
- Tree planting zone should be CLEAR of the pedestrian walking zone

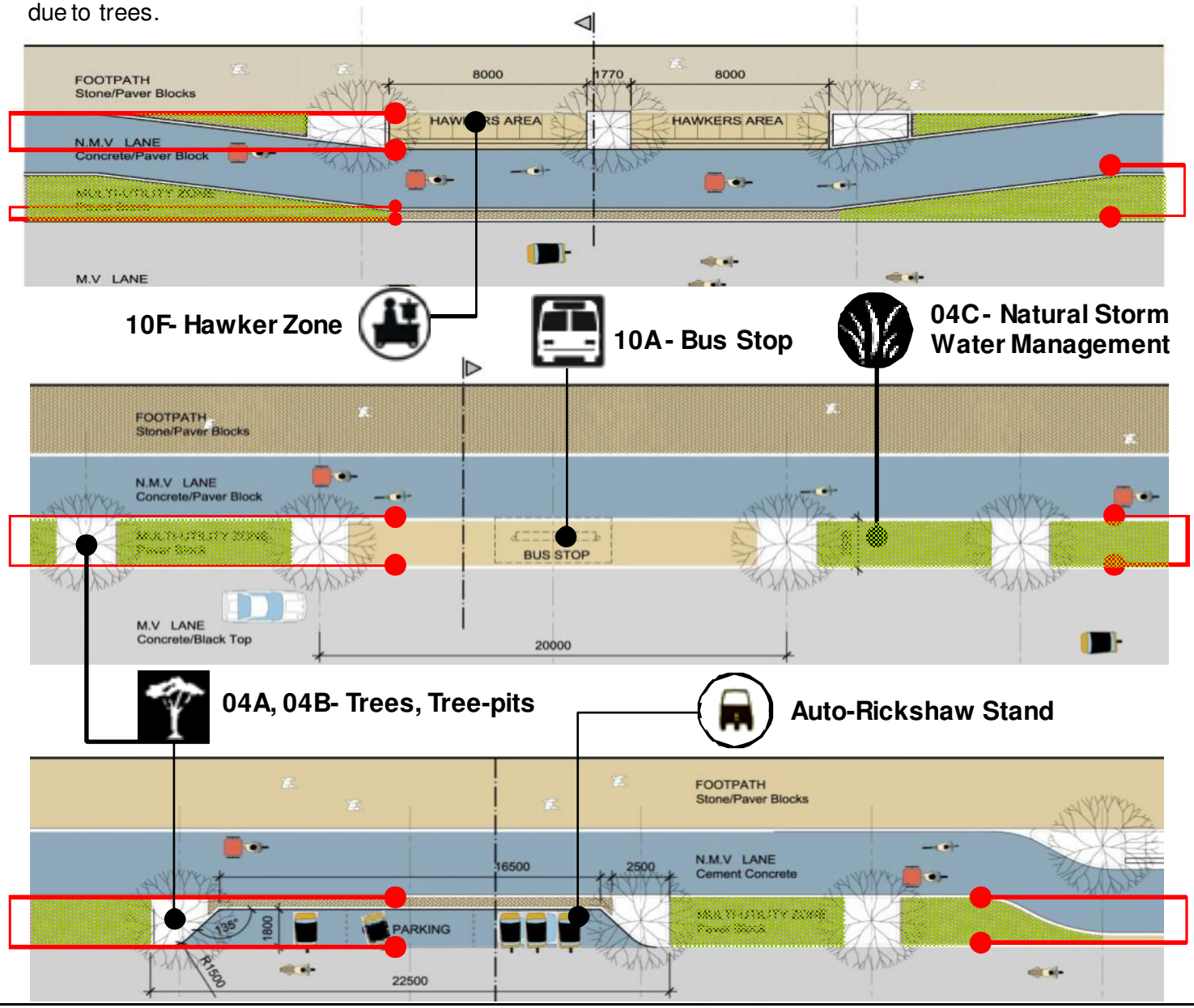
04 Multi-Functional Zone (MFZ) with Planting, Etc.

- Multi-Functional Zones on a Street should be a **minimum of 1.8 M Wide**, and may locate multiple functions.
- Provision of MFZ is most critical otherwise the uses/components of streets (mentioned to the left) would encroach upon pedestrian, NMV or carriageway space.
- Common Utility Ducts and Duct Banks **should not be** located under the MFZ as there may be interference due to trees.

04

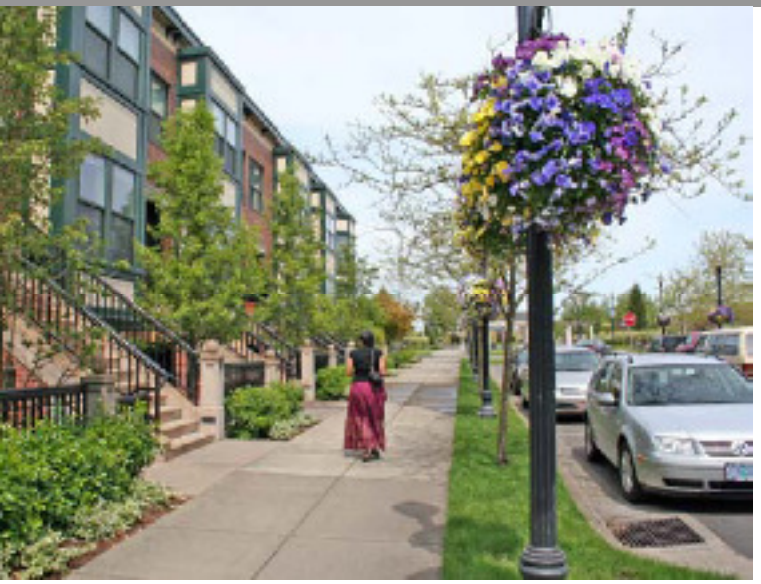
* Multi-Functional Zones on a Street may accommodate all functions described in Section 10, pg. 103, as well as the following:
  - Tree Planting
  - Planting for Storm Water Management
  - Auto-rickshaw Stands
  - Cycle-rickshaw Stands
  - Hawker Zones
  - Paid Car Parking
  - Street Furniture
  - Bus Stops
  - Traffic Police Booths, MTNL boxes, fire hydrants, junction boxes, etc.
  - Street lights/pedestrian lights.





Drawings Courtesy: Pradeep Sachdeva Design Associates, 2009

04 Multi-Functional Zone with Planting



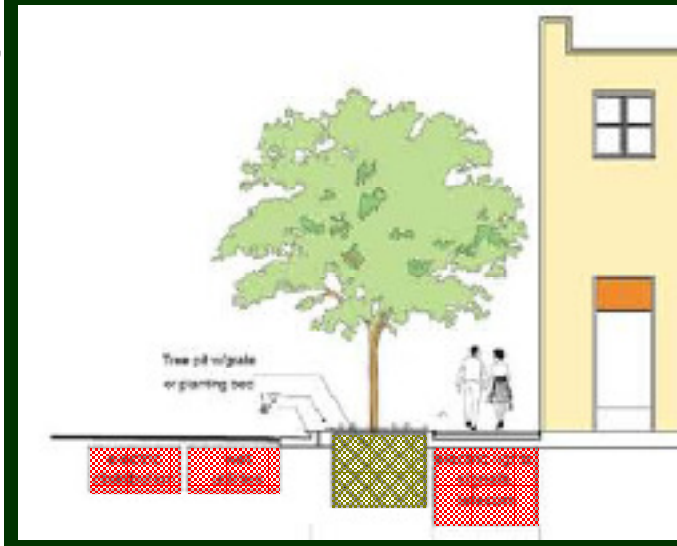
Continuous planting zones are suitable for areas where pedestrian volumes are less and they need to be contained within the walking zone.

Retail (shopping streets) should have trees in tree-guards (and not continuous planting strips) – to allow more flexibility and space for pedestrian movement.

- Pedestrian corridor and Utility Easements must be placed **separately from the Tree Planting Zone.**
- **Ideally Utilities should be placed in ducts or duct banks**, for easy maintenance.
- For the health of trees and preventing their disruption during utility repairs & other pavement activities, street trees must have the **Standard Clearances:**

From	To	Standard Clearance from Tree
Centerline of Tree	Face of kerb	3.5 feet
	Pavement or pavement landing	2 feet
	Driveway (measured from edge of driveway at pavement)	7.5 feet
	Centerline of streetlight poles	20 feet (varies by type of tree)
	Centerline of utility poles	10 feet
	Extension of cross street kerb at an intersection	30 feet
	Underground utility duct, pipe or vault	5 feet

Source: ***http://www.seattle.gov/transportation/rowmanual/manual/6_4.asp***



Not Preferable

Street Trees in same line as Utility Zone; and with low growing branches – thus obstructing walking zone.

Trees occupying walking zone, so pedestrian are displaced.

04A Essential Street Tree Planting

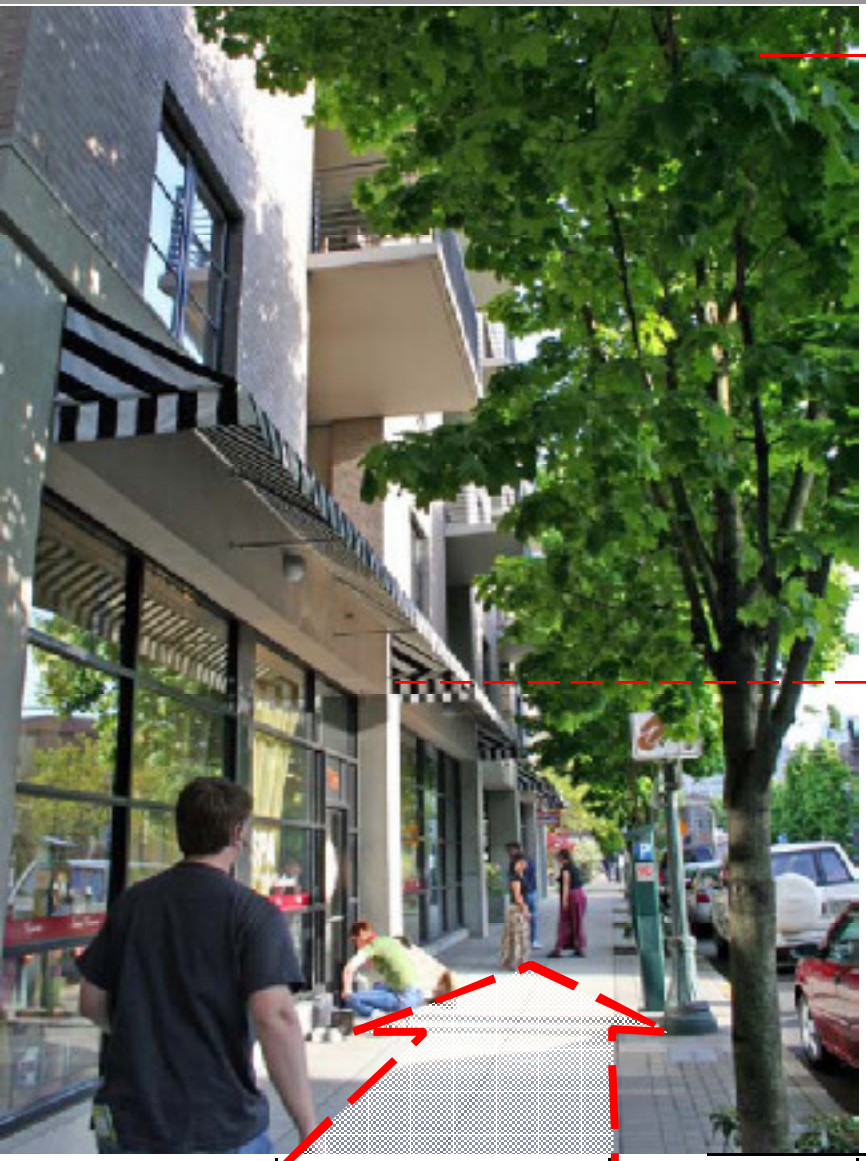
Street Trees are an essential on all Delhi Streets to provide the following:

- Provide shade to pedestrians and cyclists.
- Reduce local ambient heat through shading of surfaces and evaporative cooling - making the street more comfortable for all users.
- Absorb pollutants and improve local air quality.
- Increase local humidity so help absorb dust.
- Help create a sense of enclosure and placemaking on streets by creating relaxation spaces.
- Flowering or deciduous trees create a changing seasonal urban experience on streets.

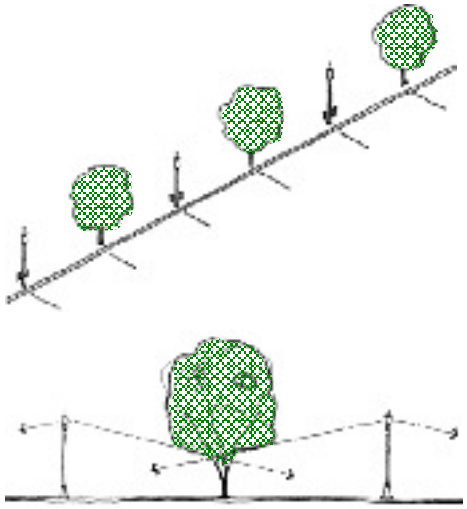
Key Design Guidelines:

- Trees are an indispensible element of streets in Delhi's harsh weather . Trees are NOT to be placed on a sidewalk as an "afterthought" or in an ad-hoc manner in left-over spaces. **Trees must be planted in the specifically allocated MFZ which is an essential requirement on all categories of streets.**
- The Clear Pedestrian Zone (minimum 1.8 M Wide) and Utility Easements/ CUDs/ Duct Banks must be placed separately from the Tree Planting Zone/ MFZ.
- **Trees must be placed such that they do not obstruct street lighting** as well as visibility of traffic signals. Therefore the Tree Planting Plan must be prepared in conjunction with the Street Lighting Plan.
- Trees must be **pruned from the bottom** such that all safety devices, signage and traffic signals are clearly visible to all road users.
- Before the start of every project, all **existing trees** must be identified, numbered and marked on a Survey Plan and **kept intact as much as possible.**
- **Deciduous Trees** that shade in summer and shed their leaves to let sunlight through in winter are ideal for Delhi.
- **Only Native trees** should be planted on streets in order to minimize irrigation requirements and prolong tree life.
- Trees like Eucalyptus, Australian Acacia, Lantana, Lucena, Mast tree (False Ashoka) **should be avoided.**

04A Essential Street Tree Planting



- Narrow "columnar" trees to be used where pavement space is limited.
- Use trees that can be "pruned bottom-up" to allow vision clearance.
- Use deciduous trees to allow sunlight access to street in winter.



Tree planting plan and Lighting plans must be prepared in conjunction – so that tree canopies do not obstruct lighting for road users.

Best Practices

Ideally, provide "wide spread" but high canopied trees for shade in summers.

Utilizing deciduous trees is advisable on busy streets where sunlight is desirable in winter.

Current Situation

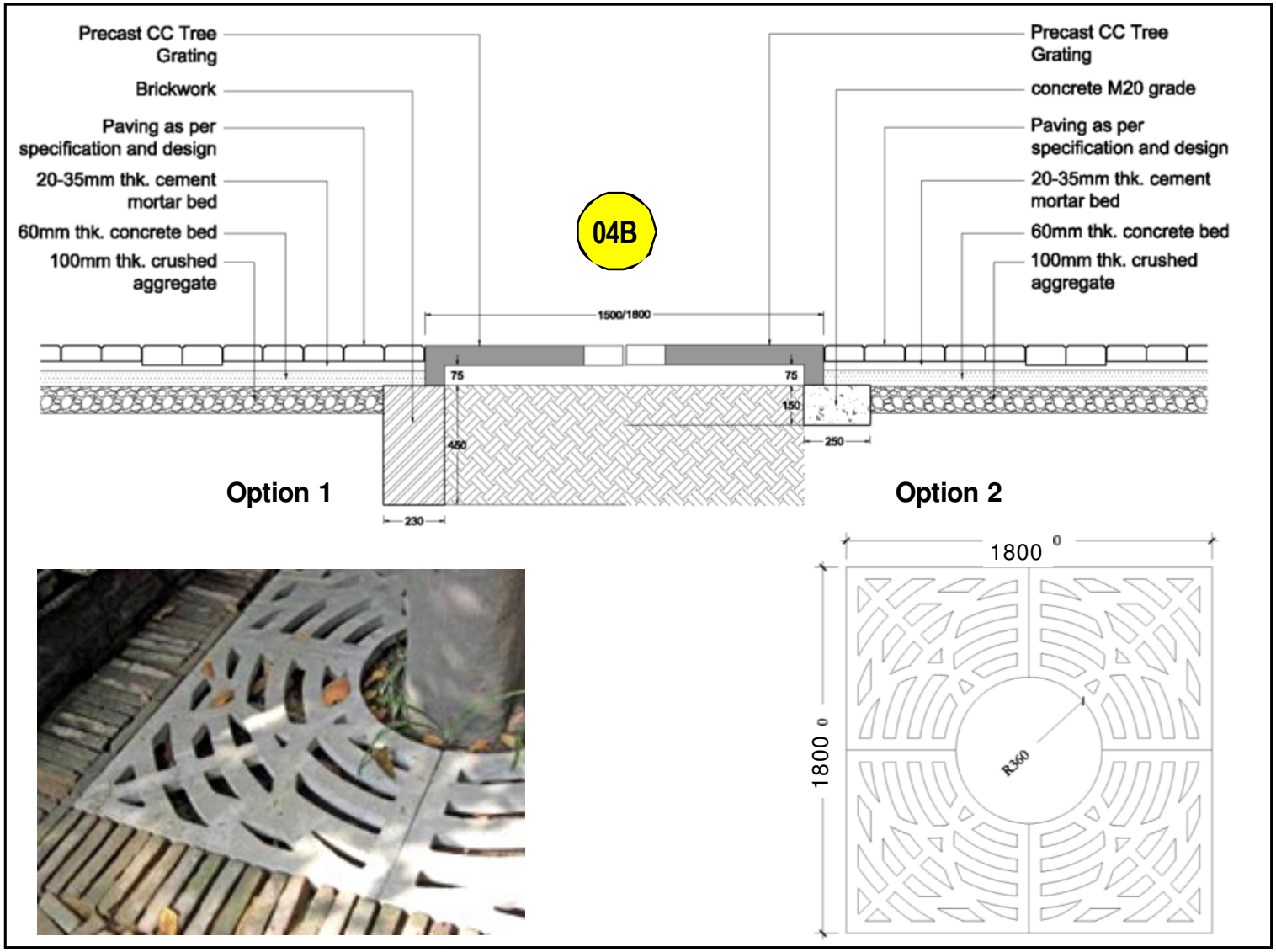
Suffocated Tree pits

- Delhi High Court, the city government said on 28 Oct 2009 it would ensure "breathing space" for every tree in the Capital — by keeping a circumference of 6 feet around it concrete-free.
- The assurance came in reply to an HC Petitioner who tells HC that concrete pavements are weakening tree roots, cutting off their water supply. This leads to 'slightest of storms' uprooting several trees, leading to traffic jams

Open Tree pits are acceptable but they are difficult for pedestrians to walk over.

04B Tree Pits and Tree Grates

- **A clear width of 1800 x 1800 M is to be left free of concrete, in order to allow access of nutrients to the roots of trees.**
- **Tree Grates allow pedestrians to walk close to trees, without discomfort to either.**



Sample Detail of Precast Cement Concrete Tree Grating.
Source: Pradeep Sachdeva Design Associates, Nov 2009

04B Tree Pits and Tree Grates

- **Tree guards should be provided for young trees. Local materials like Bamboo to be used.**
- **Tree gratings finished at the same level as surrounding pavement – allow people to walk over them, while still allowing water, air and nutrients to access the roots.**

Bamboo Tree guard by PSDA

Tree guard in Mumbai

Permeable Brick-Tile Tree Pit

Permeable Cement-Tile Tree Pit

Cobble Stone Tree Pit
Source: Better Streets, San Francisco

Best Practices

Permeable Cement-Tile Tree Pit

Stormwater 'Raingarden' Tree Pit

Precast Cement Concrete Tree Grate

Note: Photos are for representational purpose only.

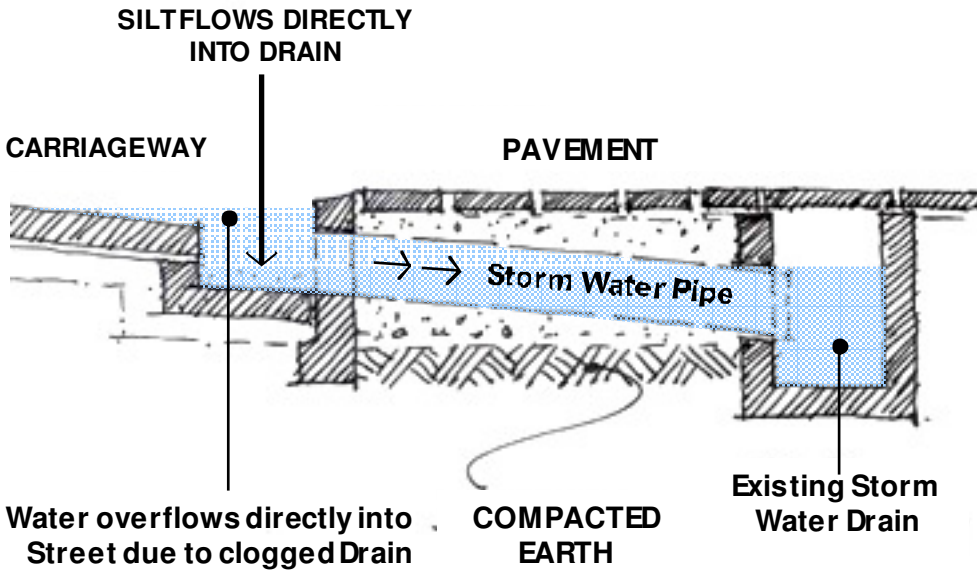
Current Situation

Silted Open Drain, Tughlaqabad Institutional Area

Overflowing Storm Water Inlet, ITO

Natural Storm Water Management can be incorporated along Planting Strips of Roads.

04C Planting Strip with Storm Water Management

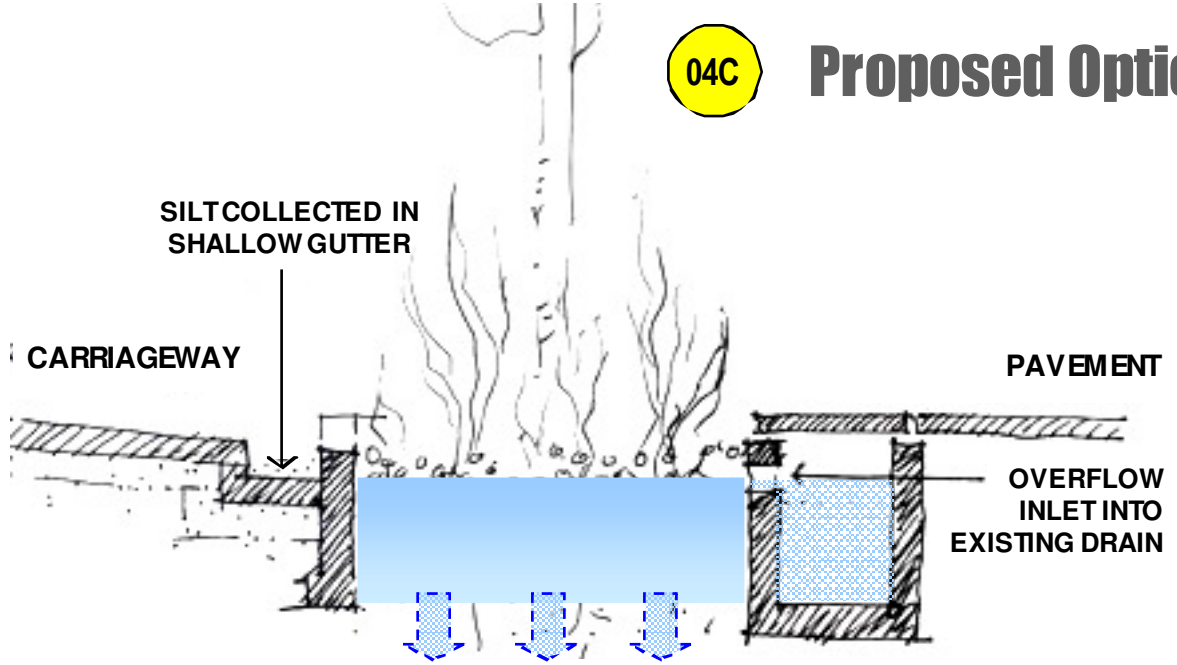


Current:

- Storm Water and Silt flows directly into the S.W. rain, carrying all pollutants with it.
- Slope of S.W. Pipe prevent rain from being used to pull capacity.

04C

Proposed Option: Bioswale



- Storm Water flows directly into a Bio-filtration or Bio-retention Swale.
- Water is retained and infiltrated in the bio-swale.
- In heavy rains, extra stormwater overflows into the existing S.W. Drain.

Sketches Source: Romi Roy, Sr. Consultant, UTTIPEC DDA, Oct 2009

04C Planting Strip with Storm Water Management

How the Science works:

Filtration:

Sediments suspended in stormwater runoff settle out and are deposited on planter soil.

Adsorption:

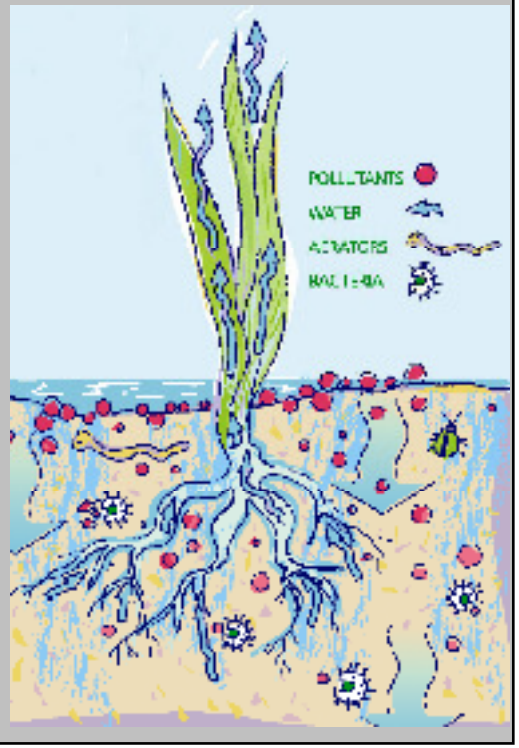
Pollutants in water attach to the surface of plants and soil particles where roots and bacteria can use them.

Storage:

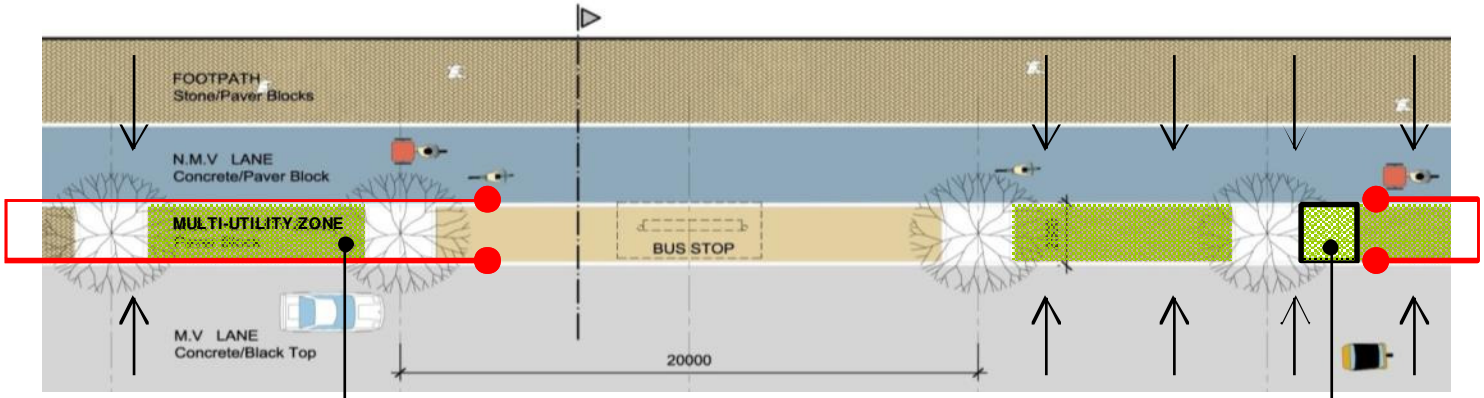
Roots, insects, and worms break up soil, making more room for stormwater runoff

Plant Uptake:

Water, nitrogen, phosphorous and trace elements are used for plant function.



- Bioswales can connect to the Main Storm Water Drain – either in Series (connected only at the end); or in parallel – i.e. each bioswale bed overflows directly into the Storm Water drain, in case of heavy rainfall.
- The Parellel Connection option is preferable.
- **Adding organic compost or mulch to soil** improves its ability to support plants and absorb stormwater. Healthy soil is the backbone of natural drainage systems.
- The following Plants maybe suitable for Delhi's soil and climate conditions:*
  - Scirpus
  - Cyprus
  - Canna
  - Typha
  - Phragmites



See Appendix-I for Details

04C **Bio-Swale within the Multi-Functional Zone**

Intermediate Storm water 'Percolation Pits'

Best Practices

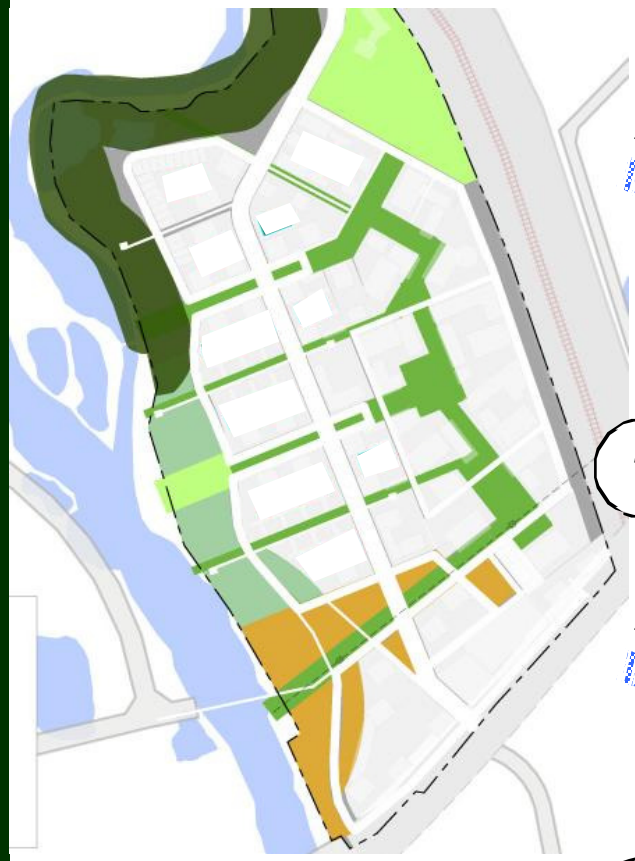
"Green Streets", Portland.

Photos: Seattle Department of Transportation.

*Plant species are suggested by NEERI

04C-a 3-STEPS for Natural Storm Water Management

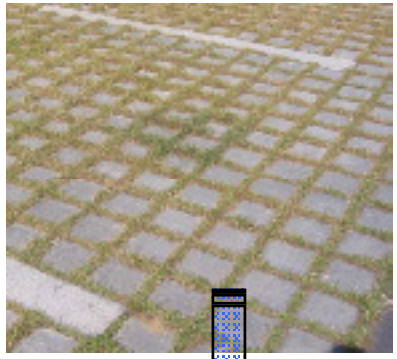
Areas that could be used for Storm Water Management in Roads:



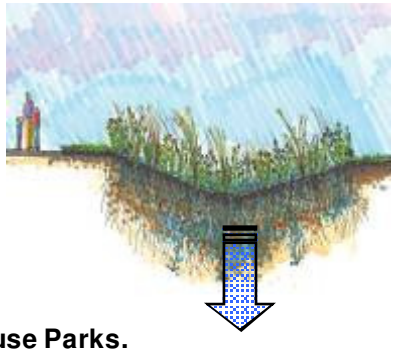
Example: An Integrated Landscape Plan

- 3 — Protected & Constructted Wetlands
- 1 2 — Urban Drainage & Linear Park System
- Neighborhood Park / Open Space
- Urban Recreation Zone

Three-step City-level Natural Treatment process:



1 **Treat/ Infiltrate at Source: "Living Streets".**
Use street-swales or raingardens to filter and convey water naturally. This saves on piping cost, while providing additional greenery.



2 **Capture and Convey Naturally: Multi-use Parks.**
Parks and Open spaces should be multi-used as retention ponds during rainy seasons.

3 **Final treatment** of remaining storm water can take place at a natural treatment **wetland** or drain into the Existing Storm Water Drain.

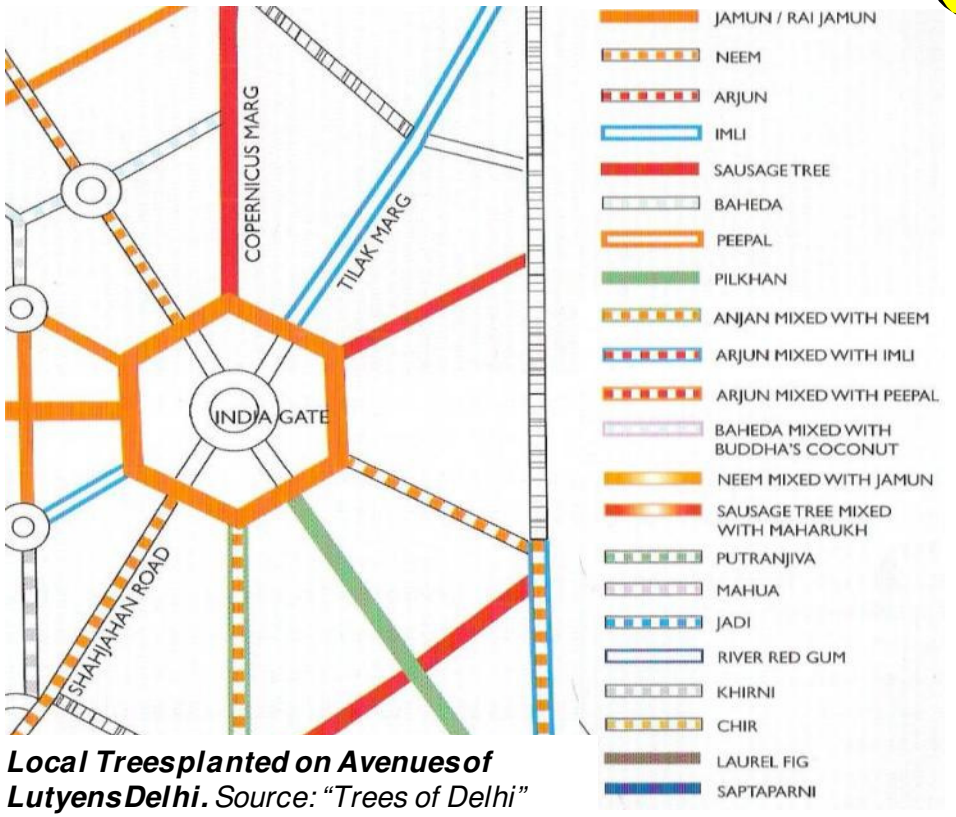
04D Aesthetic Street Tree Planting

- **Deciduous Trees** that shade in summer and shed their leaves to let sunlight through in winter are ideal for Delhi.
- **Only Native trees** should be planted on streets in order to minimize irrigation requirements and prolong tree life.
- Trees like Eucalyptus, Australian Acacia, Lantana, Lucena, Mast tree (False Ashoka) **should be avoided.**

04D


Kachnar


Tesu



Local Treesplanted on Avenuesof LutyensDelhi. *Source: "Trees of Delhi"*

Example:

Street Tree Typologies proposed Streetscaping of Streets for Commonwealth Games 2010:

Avenue Trees:

- Arjun, Terminalia arjuna
- Kusum, Schleichera oleosa
- Imli, Tamarindus indica
- Kanak Champa, Pterospermum
- Chikrassy, Chukrasia tabularis
- Mahua, Madhuca indica

Accent Trees:

- Kachnar, Bauhinia variegata
- Barna, Crataeva adansonii
- Tesu, Butea monosperma
- Tota, Erythrina variegata
- Tabebuia, Tabebuia aurea
- Jacaranda, Jacaranda mimosifolia

Best Practices


"Lutyens New Delhi

Shown above: Imli (Tamarind) Trees on Akbar Road in April (top) and February in autumn (bottom).

- Streets could be "themed" based on the seasonal colour of foliage, flowers and fruits – in order to give a unique and beautiful urban experience to Delhiites.
- Deciduous trees provide shade in summer; change colour of their leaves in autumn; and shed leaves and let the sun through in winter.

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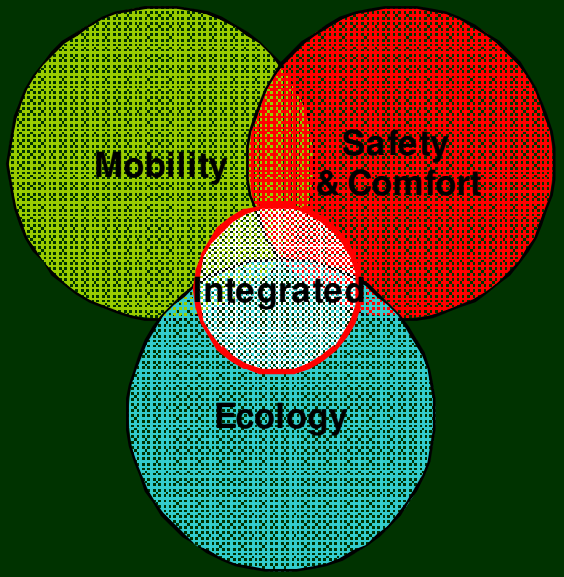
05 Bicycle and Non-Motorized Transport Infrastructure

05A Segregated Cycle + NMT Tracks

05B Bicycle Parking and Other Infrastructure



Provision for introducing cycle tracks, pedestrian and disabled friendly features in arterial and sub-arterial roads is a must. (MPD-2021)

Bicycles, Rickshaws and other Non-Motorized transport are essential and the most eco-friendly feeder services to and from MRTS stations. **They are also indispensible for short & medium length trips for shopping, daily needs, school, etc.** Providing safe and segregated NMT lanes on all Arterial and Collector Streets would encourage their use and reduce the dependency of people on the private car...

MAIN PRINCIPLES:

Mobility
- Continuous and safe NMT lanes with adequate crossings are essential throughout the city
- Ample parking facilities for NMTs must be provided at all MRTS stations

Ecology:
- The most eco-friendly mode of transportation.

Safety/Comfort
- Safe crossings for NMT are essential for their safety.
- NMT lanes must be segregated from faster motorized traffic.
- Shade must be provide along NMT lanes as well as at traffic signals.

Not Preferable

'Marked' Cycle Lanes have failed in Delhi as vehicles freely drive and park on these cycle lanes.

Marked lanes also suffer from lack of visibility.

Lack of physical separation also deprives cycles of safety and does not allow them to pick up speed.

Mixing of modes slows down everyone and creates chaos!

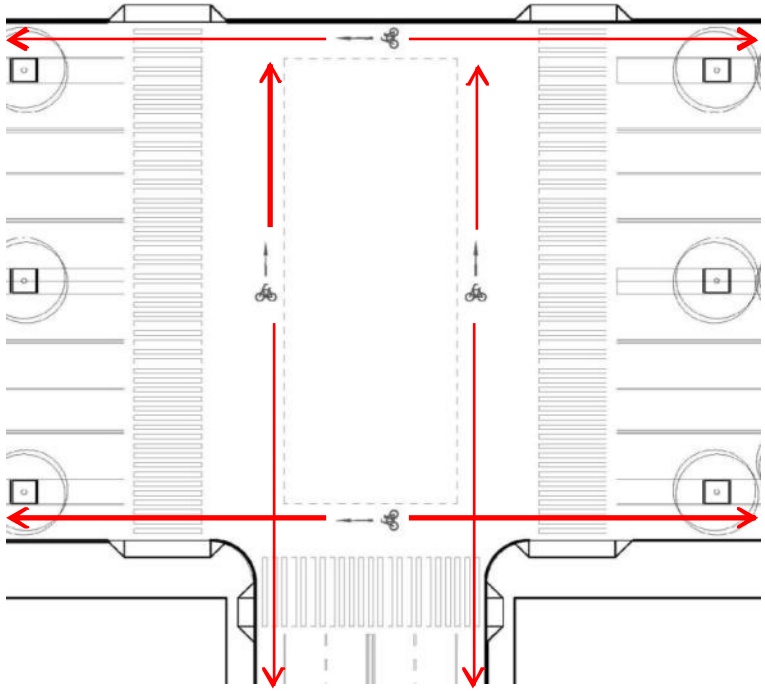
05A Segregated Cycle and NMT Tracks

Key Principles:

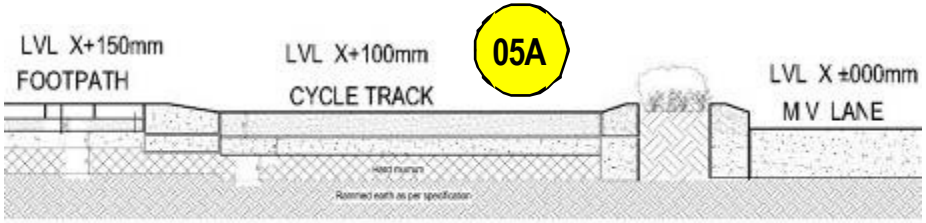
- **Cycle Lane** - A portion of a roadway that has been **designated by striping, signs, and pavement markings** for the preferential or exclusive use of bicyclists.
- **Cycle Track** - A Track intended for the use of bicycles that is **physically separated from motorized vehicle traffic** by an open space or barrier within the existing ROW.
- Provision for introducing cycle tracks, pedestrian and disabled friendly features in arterial and sub-arterial roads is a must, as per **MPD-2021. Minimum acceptable Width for single lane movement is 2.0 M.**
- **NMT Lanes are meant for Bicycles, Cycle-Rickshaws, Hand pushcarts, Hawker carts, animal drawn carts, etc.**

Key Guidelines:

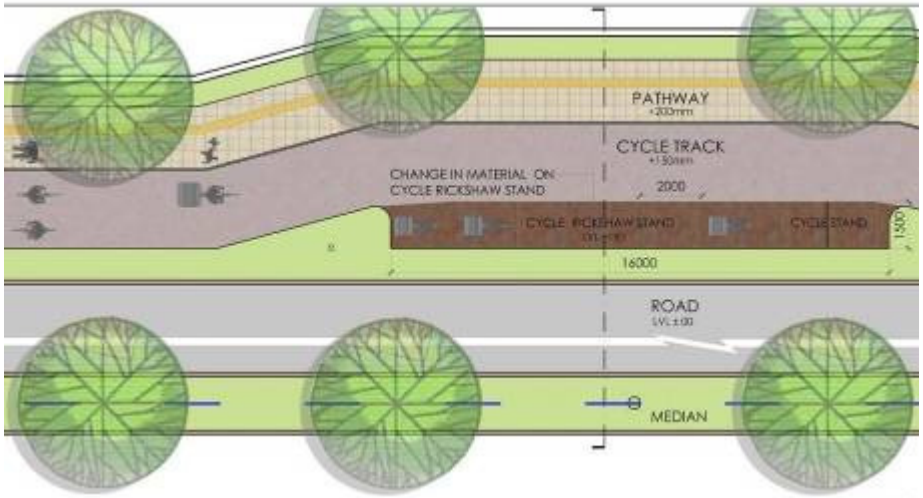
- NMVs are the second most vulnerable group of road users and therefore must be clearly **segregated from faster moving motorized traffic, especially on Roads designed for motorized speeds of**
- The NMV lane should be constructed with **smooth-finished cement Concrete or Asphalt** in order to ensure a low maintenance and smooth riding surface. In the absence of this, cyclists will tend to move into the MV lanes which may be more comfortable.
- **Minimum Dimension of NMV Track is 2.5 M.**
- NMV Lanes or Tracks should be located on both sides of the street.
- **A 0.7 M landscaped buffer should be kept between NMV and MV lanes** in order to maximize the speed, efficiency and capacity of the NMV Lane.

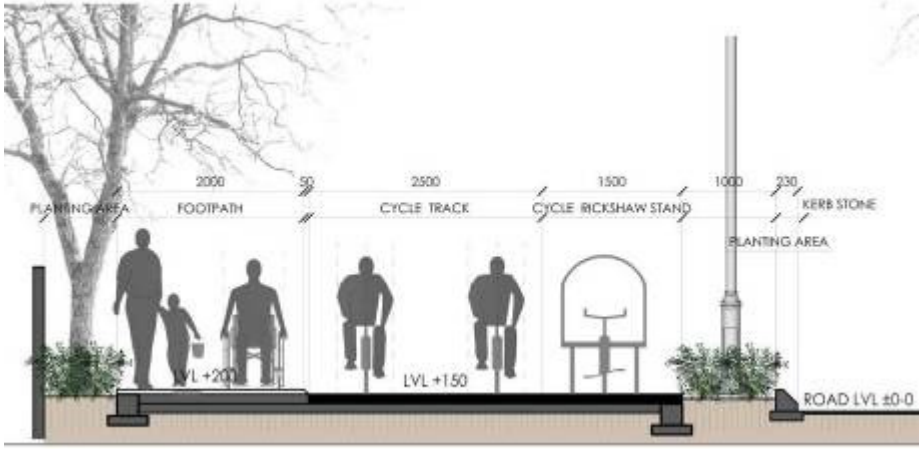


NMV lanes must be given clear crossing Tracks at junctions.



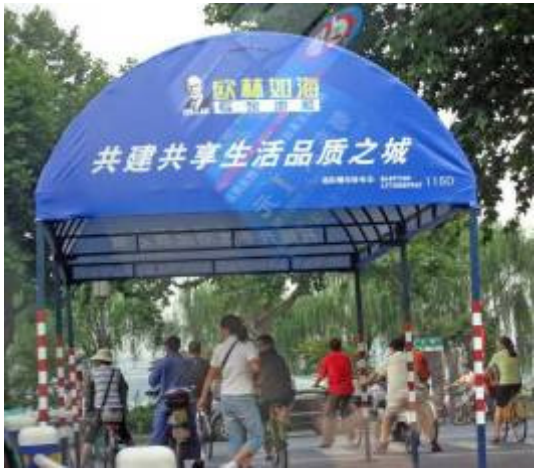
Relative Levels of NMV Tracks and Footpaths.
Source: TRIPP, IIT Delhi, BRT Design Specifications, 2009





2.5 M is the Optimum Cycle Track Width. 1.5 M Width is required for Cycle Rickshaw Parking. Detail Source: Oasis Designs Inc.

Cycle track on Public Staircase, Europe



Shaded Waiting Area for Cycles at Road Junction, Hangzhou, China

Best Practices

Segregated Cycle-NMV Track,
BRT Corridor, Delhi

Segregated TWO-WAY Cycle Track,
Canal Street, Manhattan

Segregated Cycle Track on 20 M Road, Manhattan

Not Preferable

80% of Cycles under the Paris Cycle Share Program are stolen or damaged.

Source: Samuel Bollendorff for The New York Times

Open lockable parking bays like above may not succeed in Delhi – due to fear of theft or vandalism. However, they may work as a short term (10-minute) parking option.

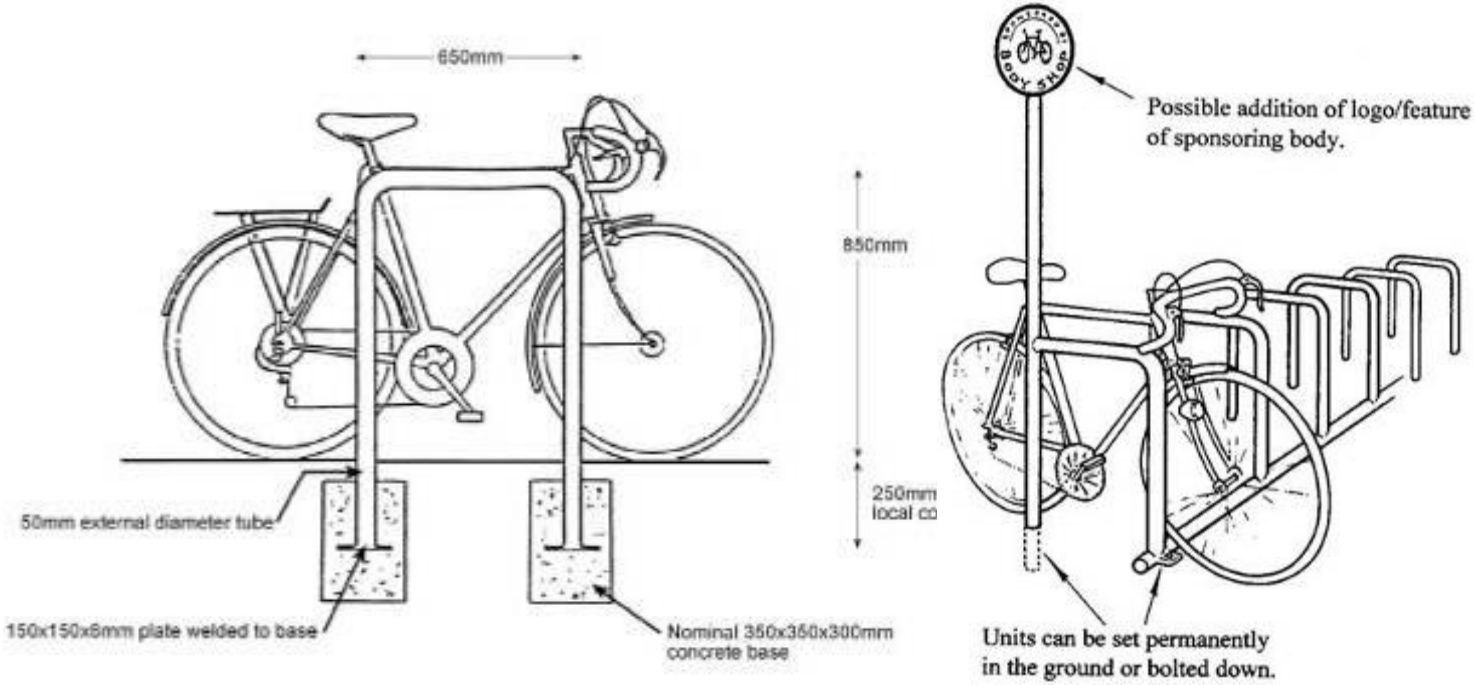
05B Bicycle Parking and Other Infrastructure

Key Principles:

- **Cycles are a very desirable and affordable private feeder service to MRTS/ BRTS Stations.**
- **To encourage their usage therefore - safe and secure cycle parking options must be provided.**
- **Secure Cycle Parking must be provided at all MRTS/ BRTS Stations.**

Key Guidelines:

- **Long-Stay Parking** – Cycle parking lots must be enclosed, ticketed (like car-parking lots) and shaded from weather. Cycle parking lots can be combined with ticket counter booths, local police booths, cycle service stations or shared areas within private building complexes.
- **Short-stay parking** – should be open to view and close to entrances of destinations.



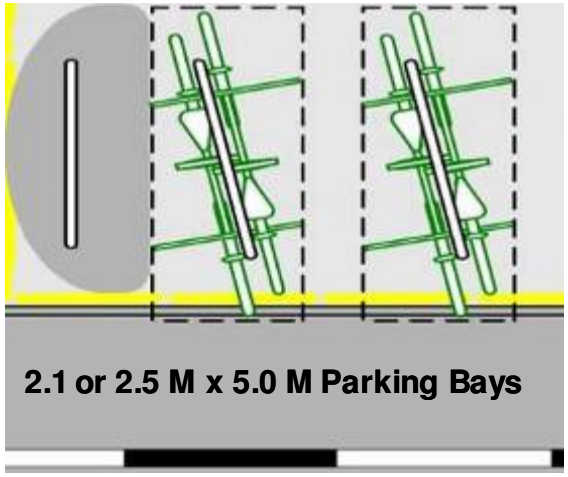
The stands should allow at least the frame and ideally both wheels, to be secured to them.

A typical Cycle Stand is shown above.

Source: http://www.norwich.gov.uk/local_plan/images/figures/diag1a.jpg

http://www.bolsover.gov.uk/localplan/ws_pics/image005.jpg

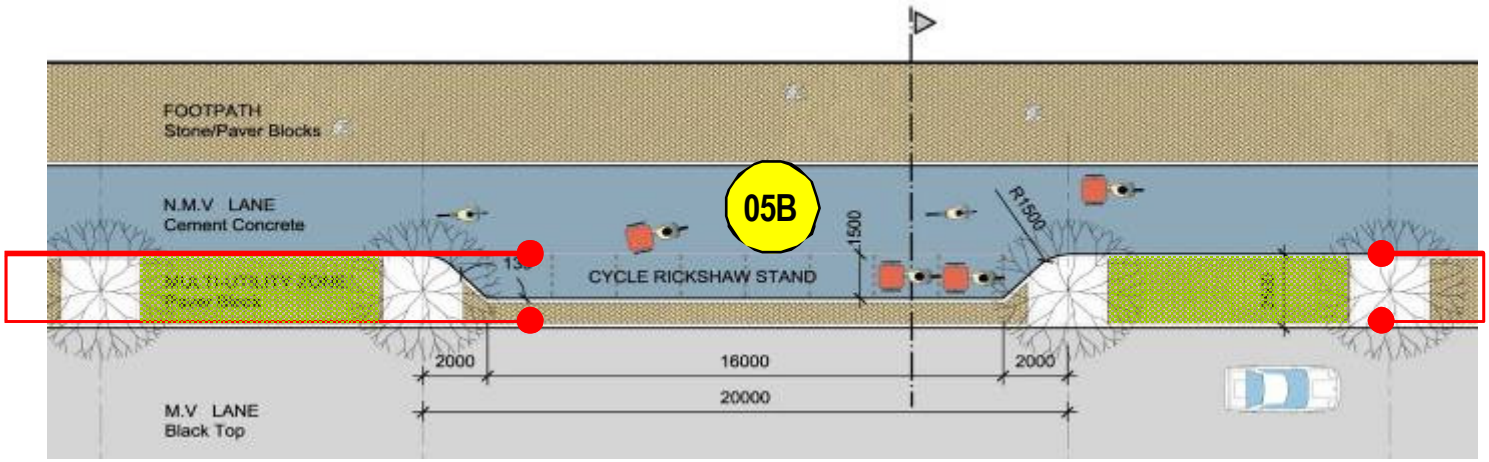
05B Bicycle Parking and Other Infrastructure



Graphic Source:
http://w ww.hackney-cyclists.org.uk/parking/on_street_x.jpg

A Cycle-repair stall next to a Cycle Track, Shanghai

SAMPLE CYCLE PARKING PLAN



Cycle Rickshaw Parking, Cycle Parking Stands, Cycle repair Stalls, etc. can all be accommodated within the Flexible **"Multi-Functional Zone" (Section 04)**

Best Practices

Public Cycle Parking in a Private Compound

Stacked Cycle Parking, China

Shaded and Ticketed cycle Parking, Beijing

Sample Drawing: Pradeep Sacheva Design Associates

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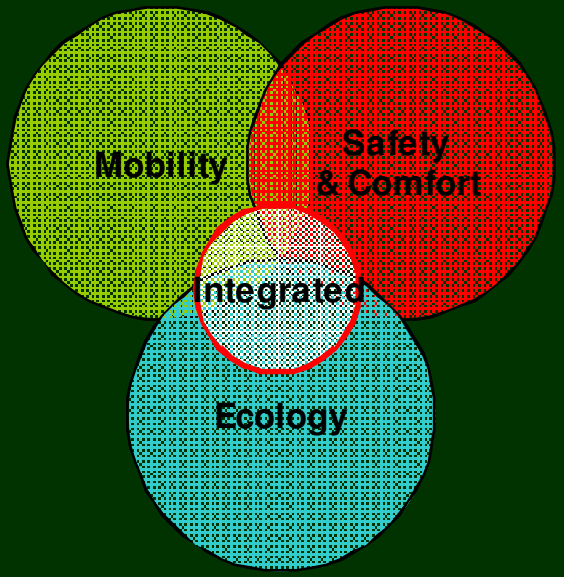
06 Crossings

- 06A At-grade Full-Signal Crossings
- 06B Pedestrian Crossings
- 06C Raised Crossings - (see 03B)
- 06D Grade Separate Crossing (Foot Over Bridge)
- 06E Grade Separate Crossing (Humped Crossing)



Marked and designated crossings are an essential part of the pedestrian realm that enable safe, convenient pedestrian travel across roadways.

Key Principles:

- Since **Pedestrians must be given the shortest possible direct route to cross the street**, the most preferred Crossing for them is “at-grade”.
- **Mid Block Crossings** must be provided for people to cross the street safely between building entries or bus stop locations or active landuses on opposite sides of the street. Mid-block crossings may be provided with pedestrian operate signals and table top crossings.
- **At-grade Pedestrian crossings must be provided at all T-junctions.**
- **Grade separated crossings could be provided on highways.**

06A At-grade Full-Signal Crossings (See also Section 10)

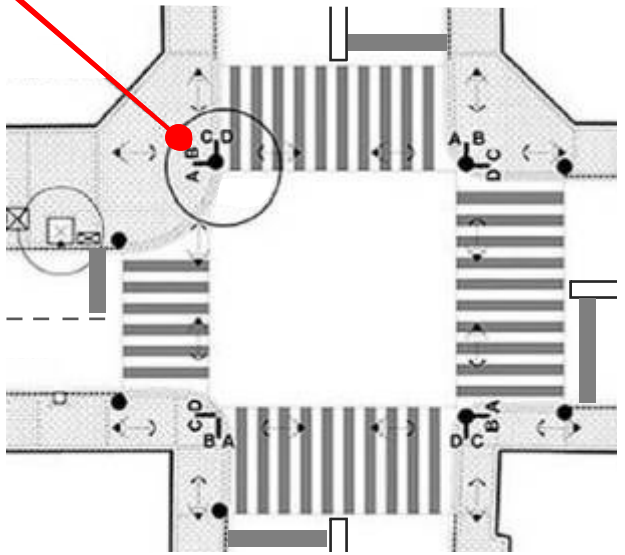
Full Signal Crossings are located either at Street junctions or at mid-block locations where the Median is punctured fully to allow crossing and full turning movements for all types or modes/vehicles.

Key Principles:*

- Crossings should be at least as wide as the sidewalk, and wider in locations with high pedestrian demand.
  - Crossings should be no less than 3 M in width. A more desirable width is 5 M.
  - Crossings must be outfitted with kerb ramps and tactile warning strips per accessibility guidelines in Section 03.
  - All light signals are to have '**auditory**' mechanism.
- **Advance stop and yield lines** should be considered at stop- or signal-controlled marked crossings with limited crossing visibility, poor driver compliance, or non-standard geometrics.
  - Stop and yield lines can be used from 1 to 15 M in advance of crossings, depending upon location, roadway configuration, vehicle speeds, and traffic control.
- **Traffic Calming** Treatment starting least 25 m before the zebra/ table-top crossing is essential in Delhi due to unruly traffic.
- **Wayfinding Signage** for Pedestrian orientation and directional guidance must be provided at street intersections. Amenities like dustbins are also needed. (Section 10)

Traffic Light Mounted Street Name Plate, with Address Range and Other Directional Signage.

See Section 10C: Signage



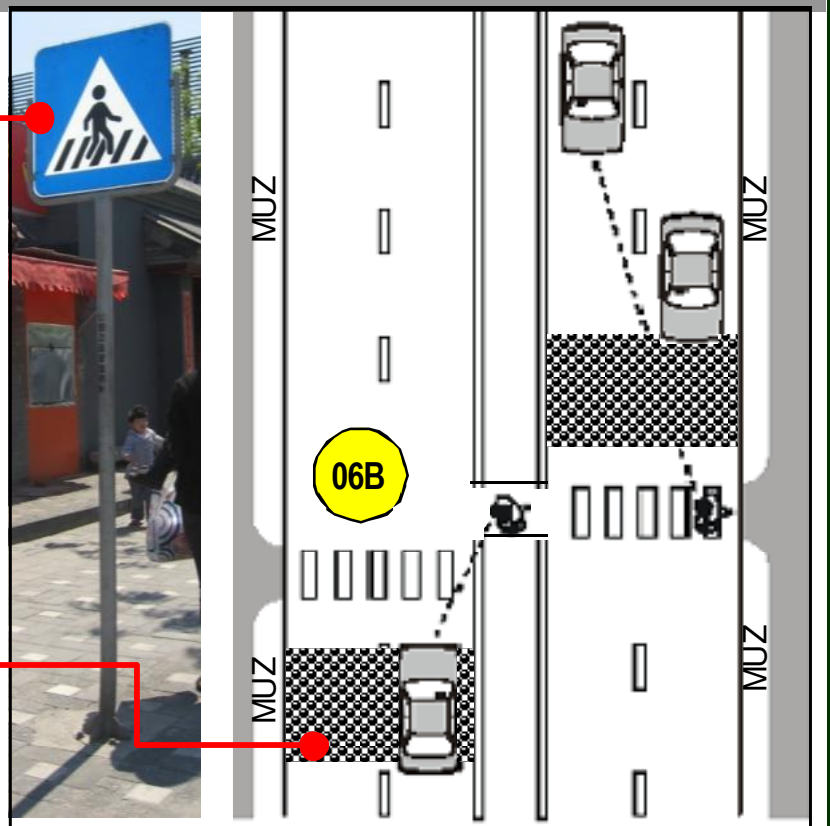
*Source: San Francisco Better Streets Plan

06B Pedestrian Crossings (See also 03B for Table-top Crossings)

Pedestrian (and NMV) Crossings are located at mid-block* locations where the Median is punctured minimally to only allow pedestrians and non-motorized modes to cross the roads safely at-grade.

Mid-block crossings must include the following:

- ❑ Signage visible from min. 100m away.
- ❑ Auditory signals are required to provide assistance to the differentially-abled.
- ❑ Traffic Calming Treatment **starting least 25 m** before the zebra/ table-top crossing.
- ❑ Minimum 20-second pedestrian signal – either as pelican or as a synchronized signal with the nearest full traffic signals.



Mid-block Pedestrian Crossings:
Signage *is Essential – to discourage Jaywalking.*
Traffic Calming *before crossings is essential for Safety.*

Mid-block crossings to be provided at:

- ➢ Mid-block transit/ bus stop locations.
- ➢ Long blocks (>250M)
- ➢ Areas with pedestrian attractors with mid-block entries like shopping areas, schools and community centers.
- ➢ **<u>Mid-block crossings must be provided at regular intervals as per following standards</u>:**

Residential Areas:	**Spacing Range: Every 80 – 250m** Coordinated with entry points of complexes; location of bus/ train stops, public facilities, etc.
Commercial/ Mixed Use Areas:	**Spacing Range: Every 80 – 150m**
High Intensity Commercial Areas:	**Pedestrianize if possible.**

*Mid-block is a location along the Street where no intersecting road exists.

**Source: "American Association of State Highway and Transportation Officials", Pedestrian and Bicycle Safety, Lesson 12 Midblock Crossings

Best Practices

** Extended Footway at Crossings provides better visibility of pedestrians and reduces the crossing distance.

Signalized Mid-Block Crossing

Signalized Table Top Crossing

Not Preferable

06D Foot Over-Bridges

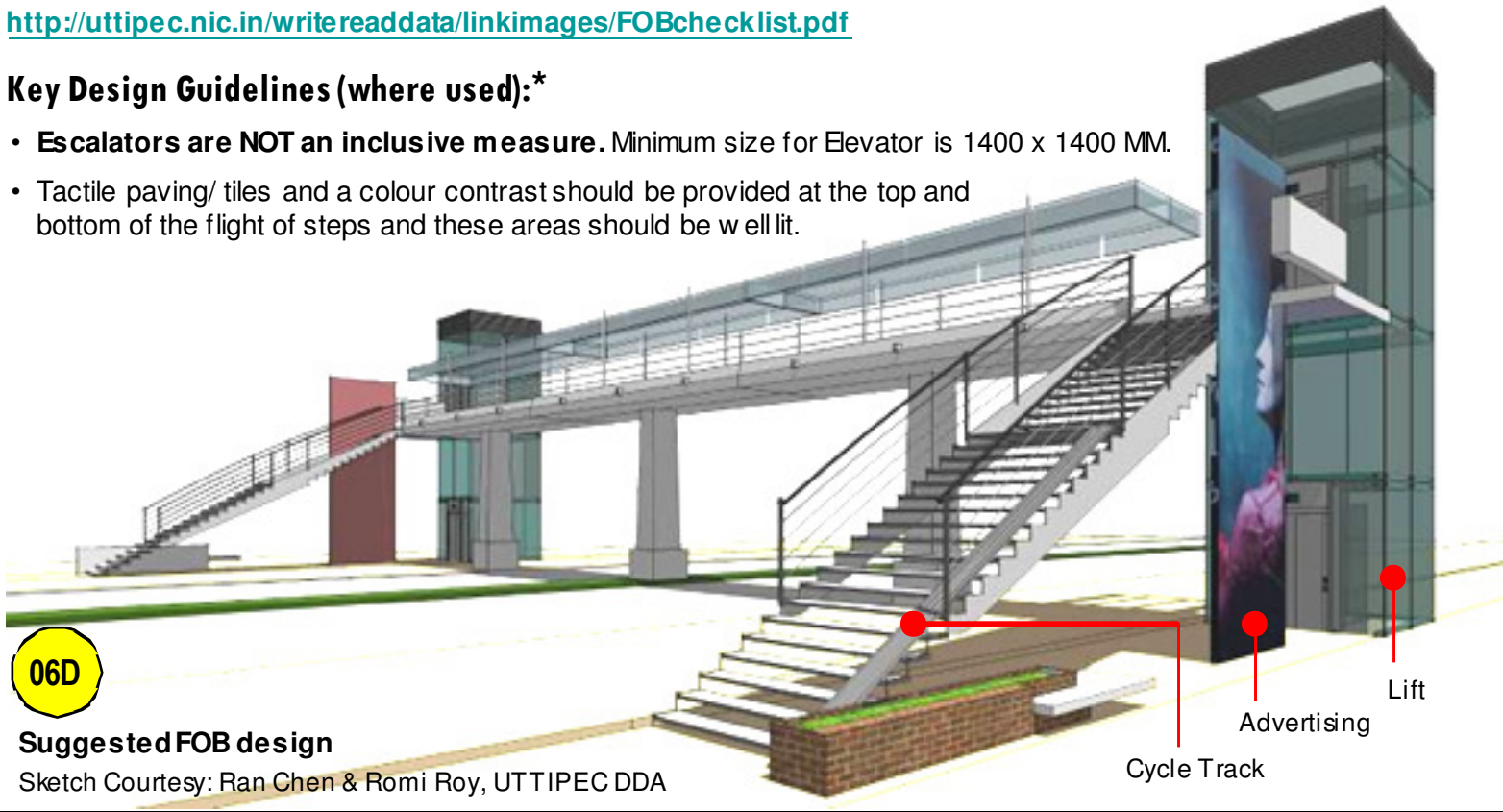
Decision of 27th Governing Body meeting of UTTIPEC:*

- **Foot Over Bridges are to be the exception, not the rule.** They are to be provided only under circumstances where no at-grade crossings are feasible.
- **Underpasses** not to be provided at all, unless under extreme circumstances where no other solutions (including FOBs are feasible).
- **At-grade crossings** (raised table-tops or zebra crossings) with pedestrian/ pelican signals and adequate signage and traffic calming measures are to be used on all Urban Roads within city limits. Pedestrian signals (approx. 20 sec.) should be synchronized along with the nearest full traffic signals along all roads, including arterials and sub-arterials, for smooth movement of traffic along with safe pedestrian/ NMV crossing.
- **All FOB proposals must be brought to UTTIPEC for approval, before implementation.**

FOB consideration checklist is available at this link on the UTTIPEC Website:
http://uttipec.nic.in/writereaddata/linkimages/FOBchecklist.pdf

Key Design Guidelines (where used):*

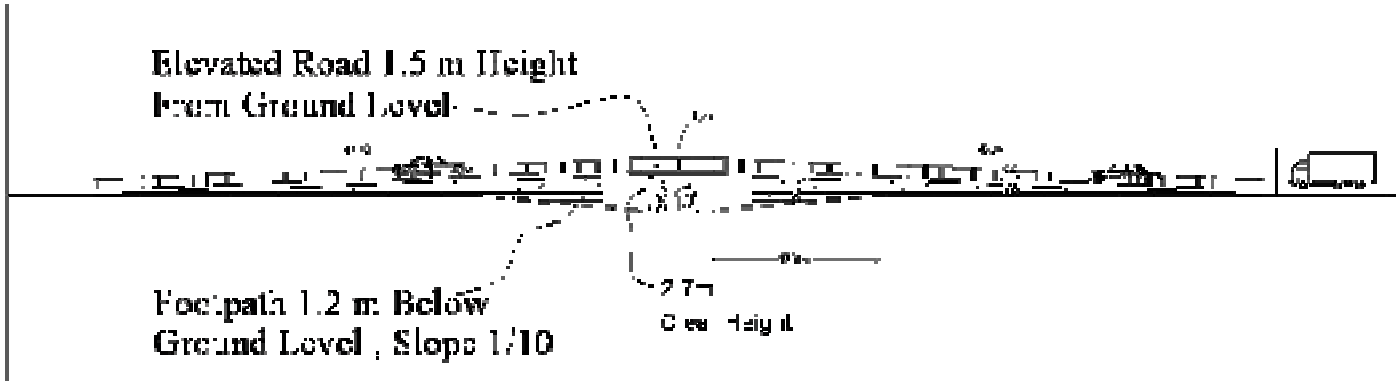
- **Escalators are NOT an inclusive measure.** Minimum size for Elevator is 1400 x 1400 MM.
- Tactile paving/ tiles and a colour contrast should be provided at the top and bottom of the flight of steps and these areas should be well lit.



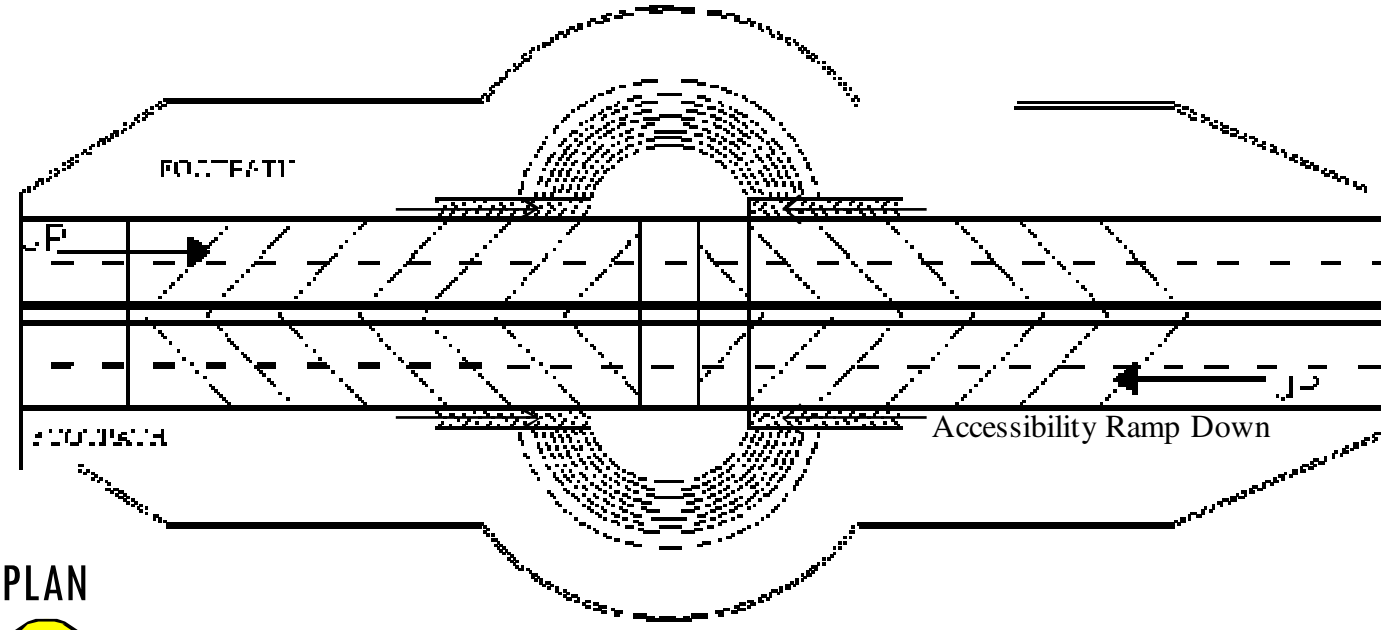
Suggested FOB design
Sketch Courtesy: Ran Chen & Romi Roy, UTTIPEC DDA

* 27th Governing Body Meeting Minutes http://uttipec.nic.in/writereaddata/linkimages/1627805538.pdf

06E Humped Pedestrian Crossings (Only on Highways)



SECTION



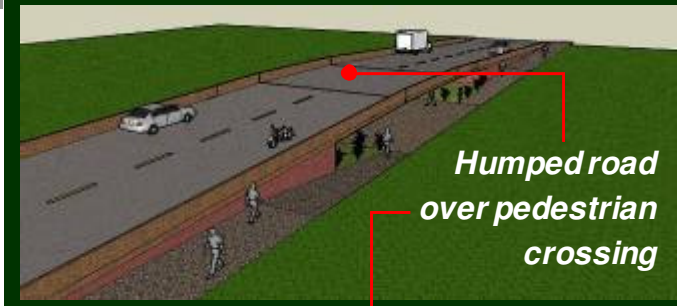
PLAN

06E

Sample Detail of a Humped Crossing (only for highways)

Source: EIL, Developments Consultant & Creative Arc Architects and Transport Planners

Best Practices



06F Other Geometric Guidelines for Cycle Tracks

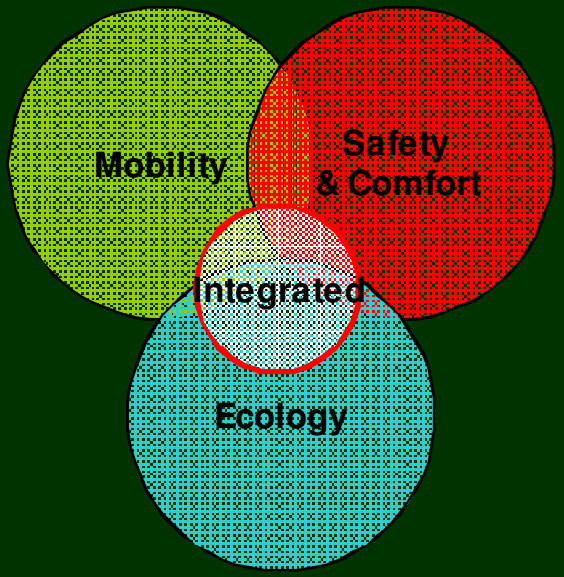
Width for One way Traffic	Two Lane - 2000 to 5000 Three Lane - Over 5000; 1000 for each additional lane
Width for Two Way Traffic	Two Lane - 2500 MINIMUM Three Lane - 2000 to 5000; 1000 for each additional lane
Cycle Track - Types	Two types of cycle tracks:
1	Which run parallel to or along a main carriageway. A. Adjoining Cycle Tracks B. Raised Cycle Tracks C. Free Cycle Tracks
2	Which are constructed independent of any carrigeway.
Cycle Track - Horizontal Curves	It should be so aligned that the radii of the horizontal curves are **not less than 10 M (33 ft).**
	Where the track has a **gradient steeper than 1 in 40**, the radii of the horizontal curves should **not be less than 15 M (50 ft).**
Cycle Track - Vertical Curves	Vertical curves at changes in grade should have a **minimum radius of 200 M (656 ft) for summit curves and 100 M (328 ft) for velley curves.**
Cycle Track - Gradients	The length of grade should not exceed **from 90 M (295 ft) to 500 M (1640 ft) for the gradient of 1 in 30 to 1 in 70, respectively.**
	Gradients steeper than **1 in 30 should generally be avoided.** Only in exceptional cases, gradients of 1 in 20 and 1 in 25 may be allowed for lengths not exceeding 20 M (65 ft) and 50 M (164 ft) respectively.
	Where the gradient of a carriageway is too steep for a parallel cycle track the latter may have to be taken along a detour to satisfy the requirements of this standard.
Cycle Track - Sight Distances	Cyclist should have a clear view of **not less than 25 M (82 ft).**
	In the case of cycle tracks **at gradients of 1 in 40 or steeper**, cyclist should have a clear view of **not less than 60 M (197 ft).**
Cycle Track - Lane width	The total **width of pavement** required for the movement **of one cycle is 1.1 M (width of a rickshaw)**
Cycle Track - Width of Pavement	The minimum width of pavement for a cycle track should **not be less than 2 lanes, i.e., 2.5 M.**
	If higher speed **overtaking** is to be provided for, the width should be made **3.0 M (9.8 ft).**
	Each **additional lane** where required should be **1.0 M (3 ft 3 in.) wide.**
Cycle Track - Clearance	Vertical clearance - The minimum head-room provided should be **2.25 M (7.38 ft).**
	Horizontal clearance - At underpass and similar other situations a side clearance of **25 cm should be allowed on each side.**
	The **minimum width of an underpass for a two-lane cycle track would**, therefore, be **2.5 M (8.2 ft)**. In such situations it would be desirable to increase the head-room by another 25 cm so as to provide a total **vertical clearance of 2.5 M (8.2 ft).**
Cycle Track - Cycle tracks on bridges	Full width cycle tracks should be provided over the bridge.
	The **height of the railing or parapet should be kept 15cm** higher than required otherwise, when cycle track is located immediately next to bridge railing or parapet.
Cycle Track - General	Provided on both sides of a road and should be separated from main carrige way by a verge or a berm.
	Minimum width of the verge - 1.0M (3ft 3in.)
	Width of verge may reduced to 50cm (20 in.).
	For a width of 50cm (20 in.) from the edge of the pavement of the cycle track, the verdge or berms shoild be maintained so as to be usable by cyclists in an emergency.
	Cycle tracks should be located beyond the hedge, tree, or footpath.
	Kerbs should be avoided as far as possible.
	A clearance of at least 50 cm should be provided near hedges and of 1.0 M from trees or ditches.
Cycle Track - Road crossings	Where a cycle track crosses a road, the carrigeway should be marked with appropriate road markings.
Cycle Track - Riding surface and lighting	Cycle tracks should have riding qualities and lighting standards equal to or better than those of the main carriageway, to attract the cyclists.

07 Medians and Refuge Islands

07A Pedestrian Refuge Island at Median

07B Median Refuge Design Options

London



A median is the portion of the roadway separating opposing directions of the traveled way, or local lanes from through travel lanes. At a pedestrian crossing, the median acts as a 'pedestrian refuge island'.

Functions and Benefits:

The provision for a **median** is a **function** of the road's **design speed**.

Medians should be provided **only** on roads where **design speeds are greater than 20/25 km/hr**.

- On such roads, medians provide greenery and also safe refuge islands for pedestrians and cyclists to wait while crossing a wide road.

Medians should generally **NOT** be provided on roads with **design speed less than 20 km/hr or R/W lesser than or equal to 24m**.

- On such roads, a **coloured thick line** may be used.
- **Absence of median** on smaller neighbourhood roads causes people to keep their **speeds under control**.
- Absence of a median also **allows for lane flexibility** during peak hours.

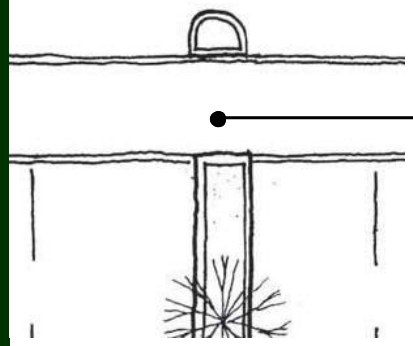
Not Preferable

Median fences totally inappropriate, especially on a residential, mixed-use, slow traffic street.

Inadequate, unusable refuge island at a signalized intersection in ITO

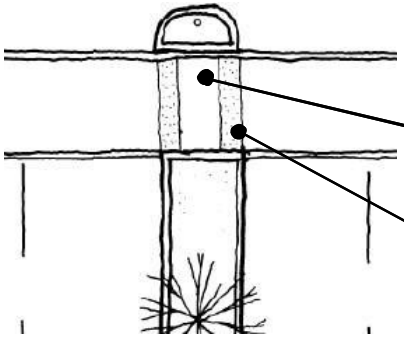
07A Landscaped Median

Median design at various widths:*



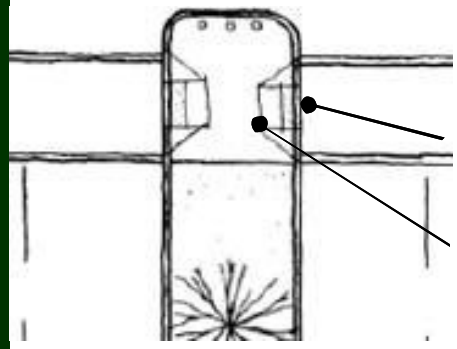
- *Timed to cross in a single phase*
- *At-grade through refuge*
- *No detectable warnings*

Median less than 2 M



- *At-grade through refuge*
- *900 MM clear waiting area*
- *600 MM tactile warnings at refuge*

Median between 3 - 4 M

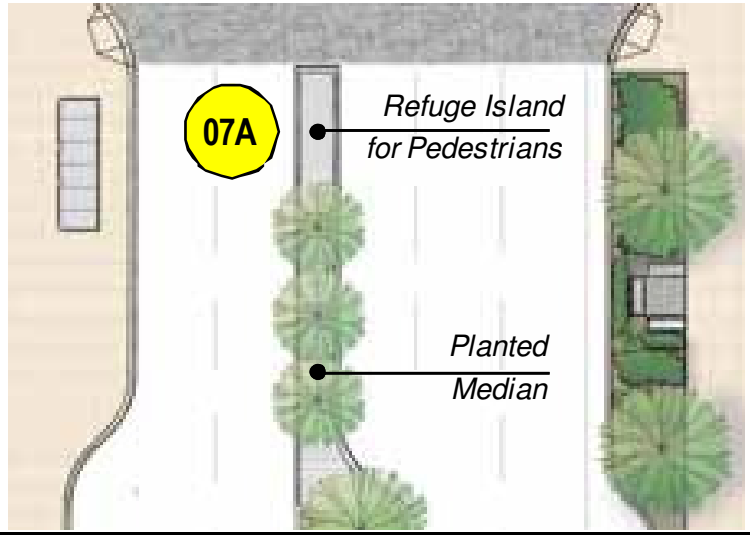


- *Raised median at refuge.*
- *600 MM tactile warnings at refuge*
- *1200 MM clear waiting area*

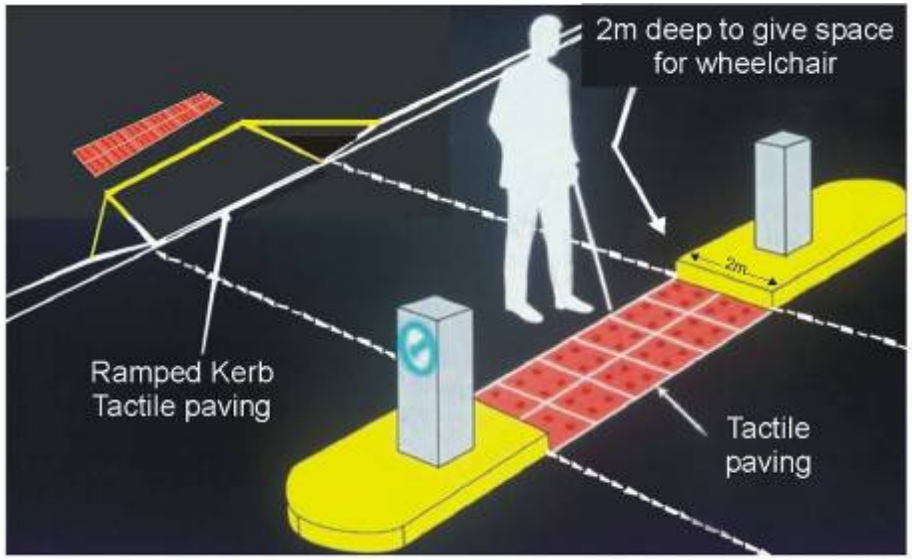
Median more than 4 M

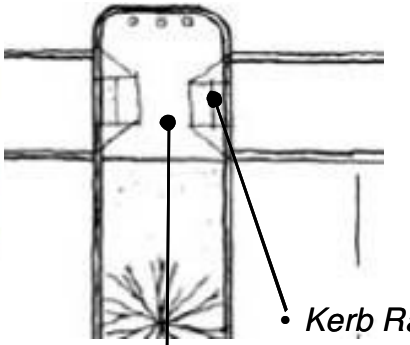
Key Design Guidelines:*

- **Maximum height of Median kerb is 150 MM. If higher medians are needed, they should be crash barriers.**
- **Instead of fences, Medians should be landscaped and used for stormwater management wherever possible.**
  - Plantings should use drought-tolerant, low maintenance species, and preferably capable of storm water filtration as well.
- When street trees are desired, **a median should be min. 1.5 M wide**, including kerbs, to provide sufficient space for healthy root growth.
  - Trees in medians can provide a fuller canopy and provide a highly cooling effect on immediate surroundings, thus reducing Urban Heat Island Effect.
  - **Clear width of a median 'refuge island' should be 1.2 M.**



07B Pedestrian Refuge Island at Median



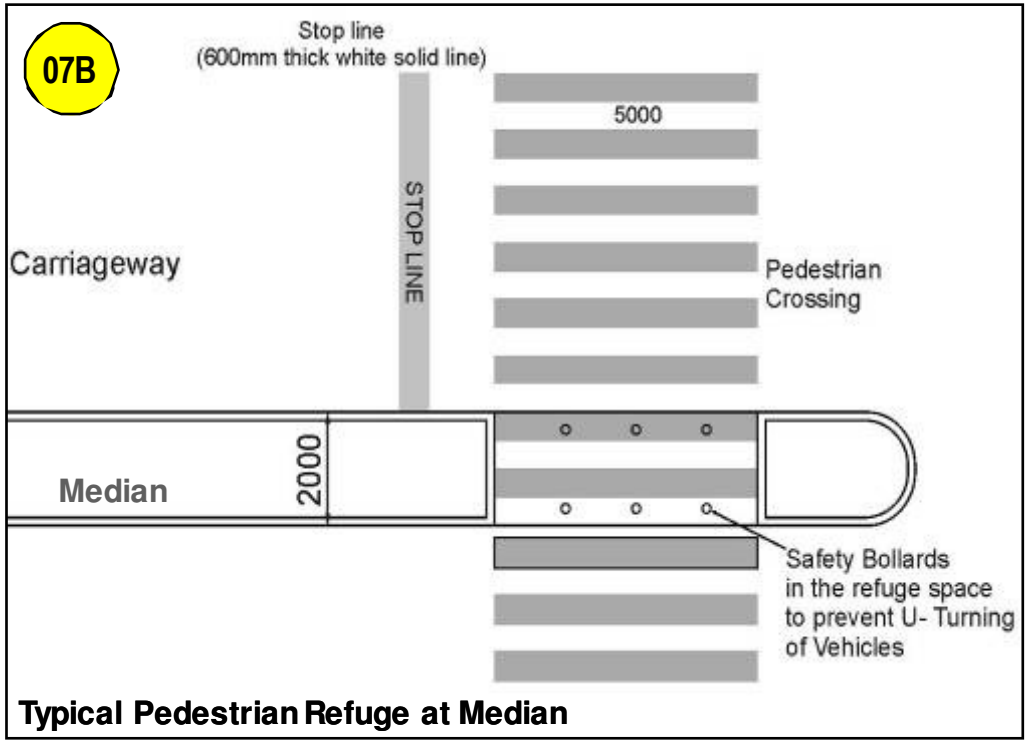


- *Kerb Ramp at Raised Median*
- ***1200 MM clear waiting area***

Raised Median more than 4 M Wide*

Kerb cuts at Median:
Tactile Paving required…

Landscaped Median, Lodhi Rd.



Typical Pedestrian Refuge at Median

(Drawing Courtesy: ICE and SG Architects)

Best Practices

At-grade Median Refuge*

Fences are futile if placed on the median.

The best use of medians is planting of trees and biosw ales: reducing Heat Island effect and ambient temperature for the street & increasing its ecological value by treating and filtering stormw ater on site.

Medians can be designed to retain, cleanse, and infiltrate stormw ater runoff from the roadw ay, replenishing groundw ater and decreasing the peak flow burden on stormw ater infrastructure.

At-grade Median Refuges allow pedestrians to w ait safely for crossing w ide streets w ith long signal rotations.

At-grade Median Refuge*

*Source: San Francisco Better Streets Plan

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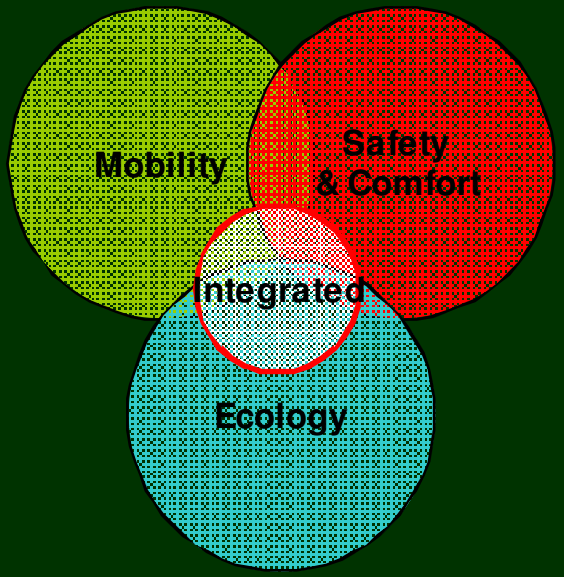
08 Street Lighting

08A Pedestrian Scale Low-Mast Street Lighting

08B Full Cut-off Fixtures



Lighting needs of pedestrians are different from those of vehicular traffic and therefore need to be designed and integrated within the overall lighting strategy for the street. This would aid the safety of pedestrians on pavements after dark.

MAIN PRINCIPLES:

Mobility	- Optimal lighting for pedestrians to provide safety and security.. - Light poles must be CLEAR of the pedestrian walking zone.
Safety/Comfort	- Provide optimal lighting for pedestrians. - Pedestrian lights should be placed lower and focusing on the pavement.
Ecology	- Provide FULL cut-off lighting fixtures to prevent spillage of light and wastage of energy, and also prevent night sky light pollution.

Not Preferable

High Mast Lighting is inefficient and ineffective especially in this narrow mixed-use street.

Light poles placed on the walkway so pedestrians are forced on to the road.

08A Pedestrian Scale Street Lighting

Intent:

- Safety of the most vulnerable road user - pedestrians.
- Increase sense of security and help keep streets active after dark.
- Provide comfortable and attractive night time visual environment.
- Reduce night-time accidents.

Key Design Guidelines:

1. **Height of Light Pole and Luminaire Type are a function of Street Width:**
   - High Mast Lighting (30 M tall) – are inefficient as too much light is dispersed into the night sky (causing light pollution) and not much light reaches the ground level.
   - Mid-Mast Lighting (10-12 M tall) – are appropriate for most Arterial and Sub-Arterial Streets. For Wide Streets with high pedestrian/commercial activity, Mid-Mast lighting may be combined with Pedestrian Scale lighting to create additional security and comfort.
   - Low-Mast or Pedestrian Scale Lighting (3-5 M Tall) – illuminate pedestrian-only walkways and provide supplemental light for the sidewalk.
2. **Different Types of Street require Different Types of Street Lighting.** Approx. 30 lux level is suitable for non-shopping areas and 20-25 lux-level for shopping areas.
3. **Key aspects of planning for Optimum Street Lighting are:**
   - **Evaluation of adjacent landuses.**
   - **Evaluation of activities (especially night-time activities)** on the street. For example, lighting requirement outside Old Delhi Railway Station would be very different from that outside Millennium Park.
   - Street Lighting must not pollute the environment, i.e. **no night sky light pollution**. ***See 08B***
   - **Energy Efficient fixtures** should be utilized that give good value for money, i.e are durable, rugged and inexpensive.
   - **Concentrated lighting** is required at all road Intersections and junctions, as well as bus stops, Metro exits, near crosswalks, street furniture, public amenities and important signage.
   - While placing street lights, ensure adequate gaps and **spacing from the tree canopies** to ensure that performance of lighting is not compromised.

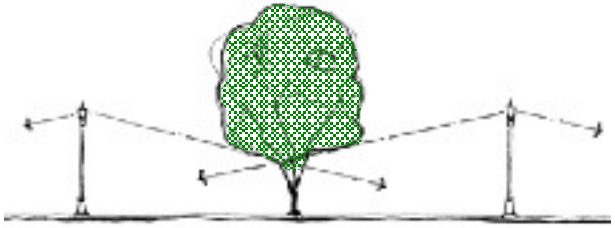
08A Pedestrian Scale Street Lighting

- **Height of Light Pole is a function of Street Width. Narrower the Street Width, lower can be the Lamp Height.**
- Expert advise should be taken from lighting engineer for design calculations including for pole height, type of luminaries, etc. for achieving appropriate lighting levels at all parts of the street.

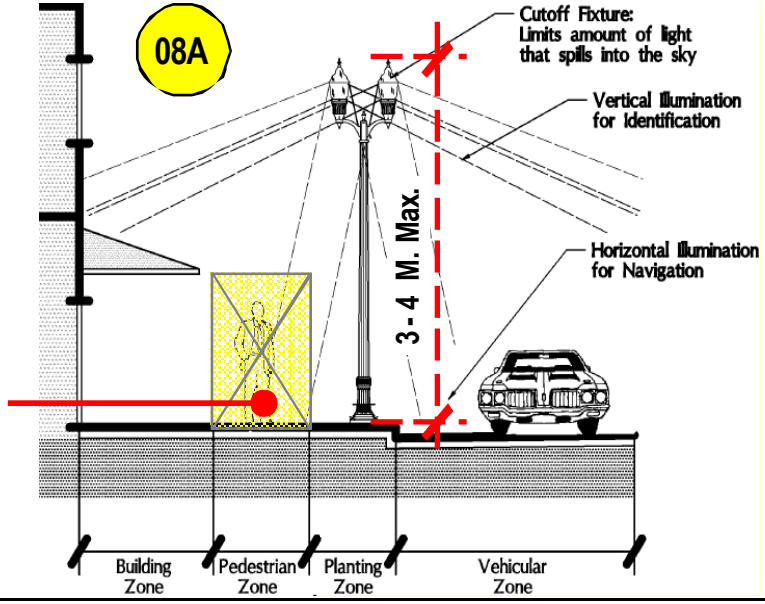
High/ Mid-Mast Lighting may not provide sufficient light at pavement level.

Additional Low-Mast Pedestrian Scale Lighting is advisable on all Streets.

30 M or narrower streets like local access lanes, alleys and pedestrian pathways can possibly be adequately illuminated with Low-mast fixtures alone.



- **Tree planting plan and Lighting plans** (See also 04A) **must be prepared in conjunction** – so that tree canopies do not obstruct lighting for road users.
- Under NO CIRCUMSTANCES should the **Light-pole placement interfere with the clearance of the main pedestrian walkway** of the pavement. Light pole may preferably be located within the tree-planting zone.

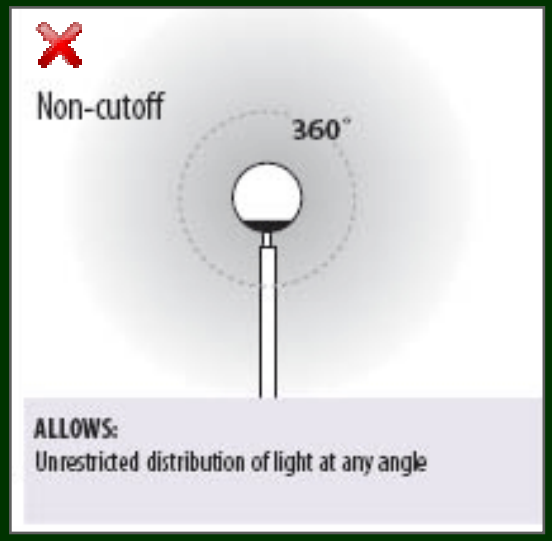


Street Lighting Fixtures also help define the unique character of an area.
Above: A historical neighborhood
Below : A modern area – both in San Francisco

Source: San Francisco Better Streets Plan

Not Preferable

Non-cutoff Street Lights often cause glare and night pollution.



08B Full Cut-off Light Fixtures

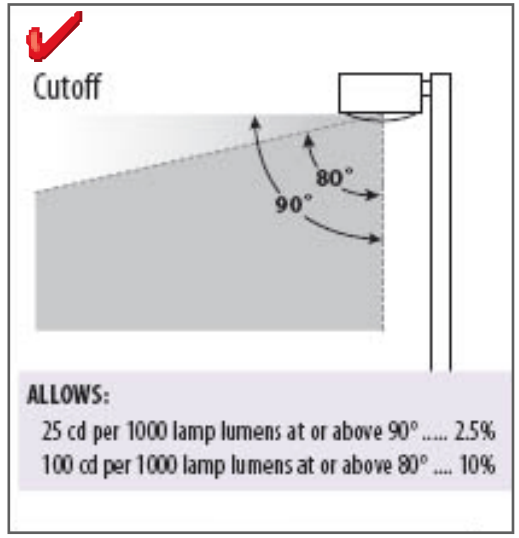
Intent:

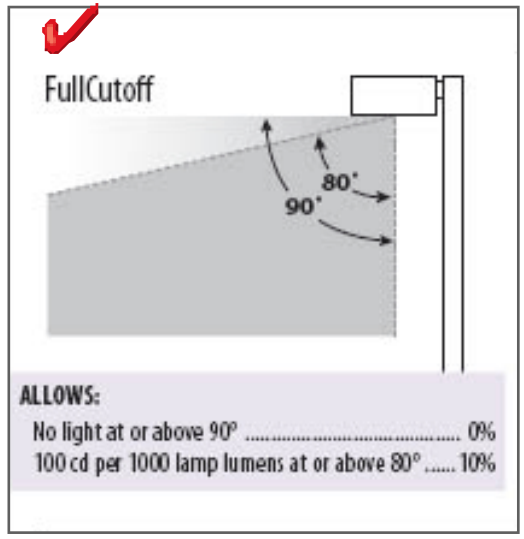
- Provide Ambient Street lighting for pedestrians without causing glare, over brightness or light pollution.

Key Design Guidelines:

- **Full cut off fixtures** which focus light downwards and allow no light towards the night sky, and also do not cause glare – are required for all public streets.
- Lighting shall be directed downward at all times (**up-lighting would be prohibited**)
- Over-lighting an outdoor area at night is NOT the best solution for security or safety. Instead, exterior lighting that provides **low contrast on critical areas** improves visual acuity and safety.
- The light color of lamps also affects safety: illuminating objects with products that have high Color Rendering Indexes (CRI) improves visual recognition at night.
- **All exterior lighting shall have shielding as per table below.**

Fixture Lamp Type	Residential Area Shielded	Commercial / Industrial Area Shielded
Low Pressure Sodium	Fully	Fully
High Pressure Sodium	Prohibited except fully shielded on streets	Fully
Metal Halide	Prohibited	Fully
Fluorescent	Fully	Fully
Quartz	Prohibited	Fully
Incandescent > 60 Watts	Fully	Fully
Incandescent 60 Watts or less	No requirement	No requirement
Glass Tubes filled with Neon, Argon, or Krypton	No requirement	No requirement
Mercury Vapor	Prohibited	Fully
Halogen	Prohibited	Fully
Search lights for advertising purposes	Prohibited	Prohibited





*Source: Cornfield Arroyo Seco Specific Plan

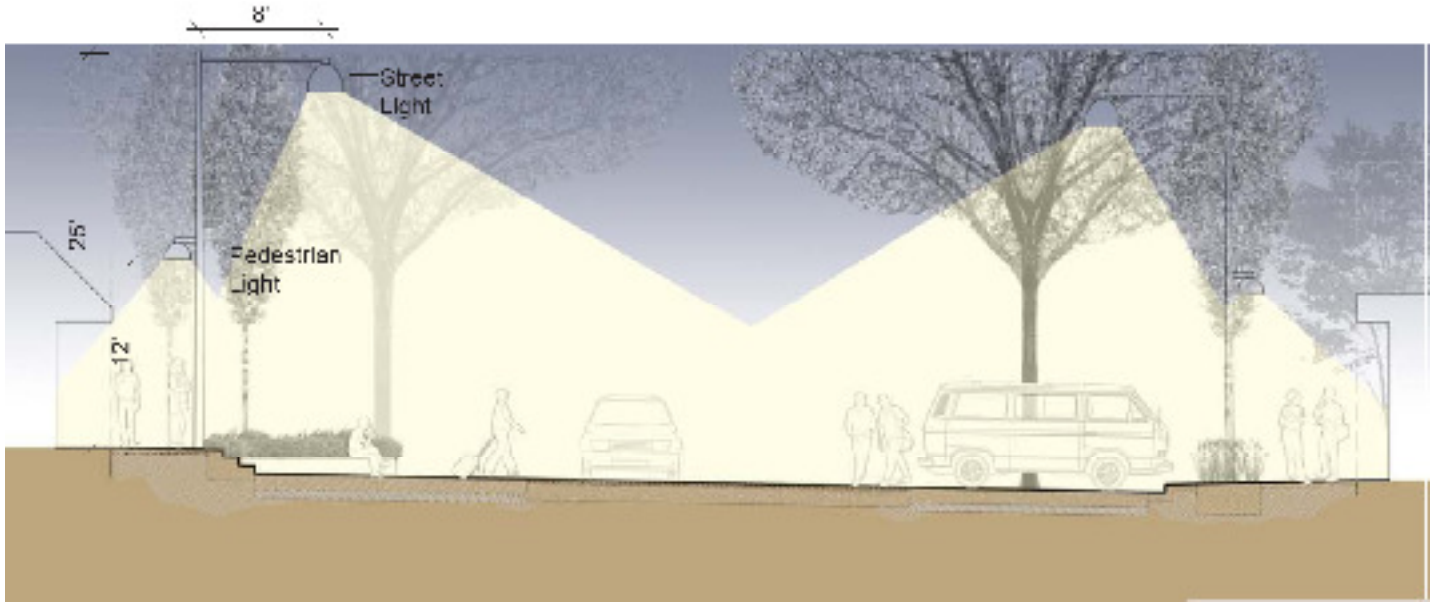
08B Full Cut-off Light Fixtures

A variety of Full Cutoff light fixtures can meet required site-specific standards:

08B

Solar LED lights

•For Wide Streets with high pedestrian/commercial activity, **Mid-Mast lighting may be combined with Pedestrian Scale lighting** to create adequate sense of security and comfort.



Graphic Source:
www.winslowwaystreetscape.org/WinslowWayStreetscape/Final_Design_files/Lighting_finalDesign.pdf

Best Practices

A poor quality light fixture causing glare and night pollution.

Uniform low ambient levels of lighting provides better visibility for pedestrians.

Source: San Francisco Better Streets Plan

Downward-facing lighting prevents excess light from trespassing into adjacent buildings

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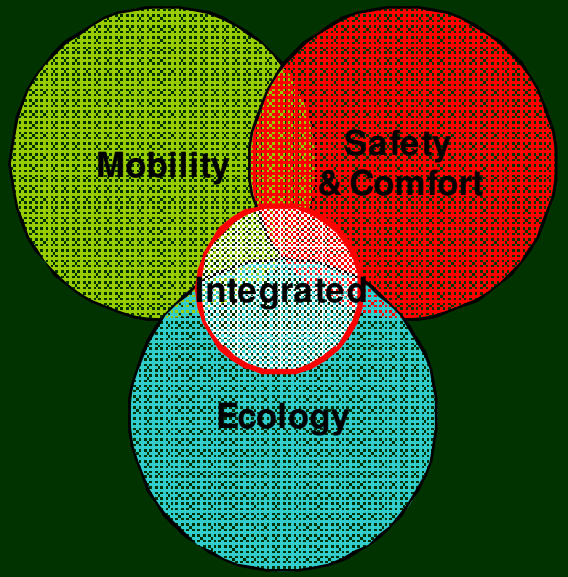
09 Urban Utilities

09A Underground Utilities

09B Common Utility Ducts

09C Duct Banks

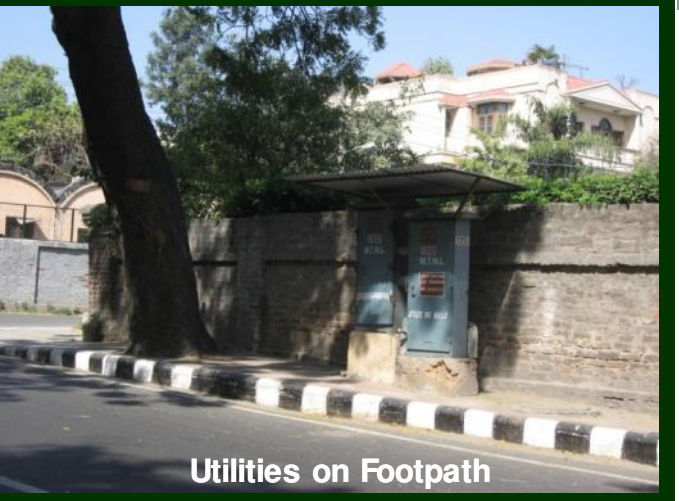


Careful location and planning of Physical Infrastructure services and Urban Utilities is critical – in order to allow easy access for regular repair and maintenance of utilities, while causing minimum disruption or disturbance to other street users.

URBAN STREET UTILITIES INCLUDE:

- Electrical Cables (HT/LT)
- Road Lighting Cables
- Communication Cables
- Cable TV
- Tele/Broadband Cables
- Traffic Signal Cables
- Gas Lines*
- Water Supply Lines*
- Unfiltered Water/Irrigation Lines*
- Drainage Lines**
- Sewerage Lines**

Not Preferable



Utilities on Footpath

Open Manholes on footpath

Dug up footpath during Utilities Repair

09A Underground Utilities

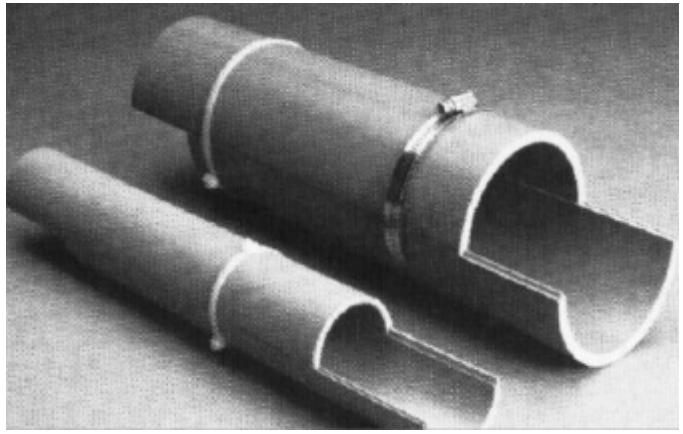
Careful location and planning of services is important in order to cause minimum disturbance to street users during repairs and maintenance of utilities.

- The street is also a carrier of urban utilities such as water lines, sewer, electrical and telecom distribution cables , gas pipes, etc. these must be located underground and in some cases over ground in a proper manner.

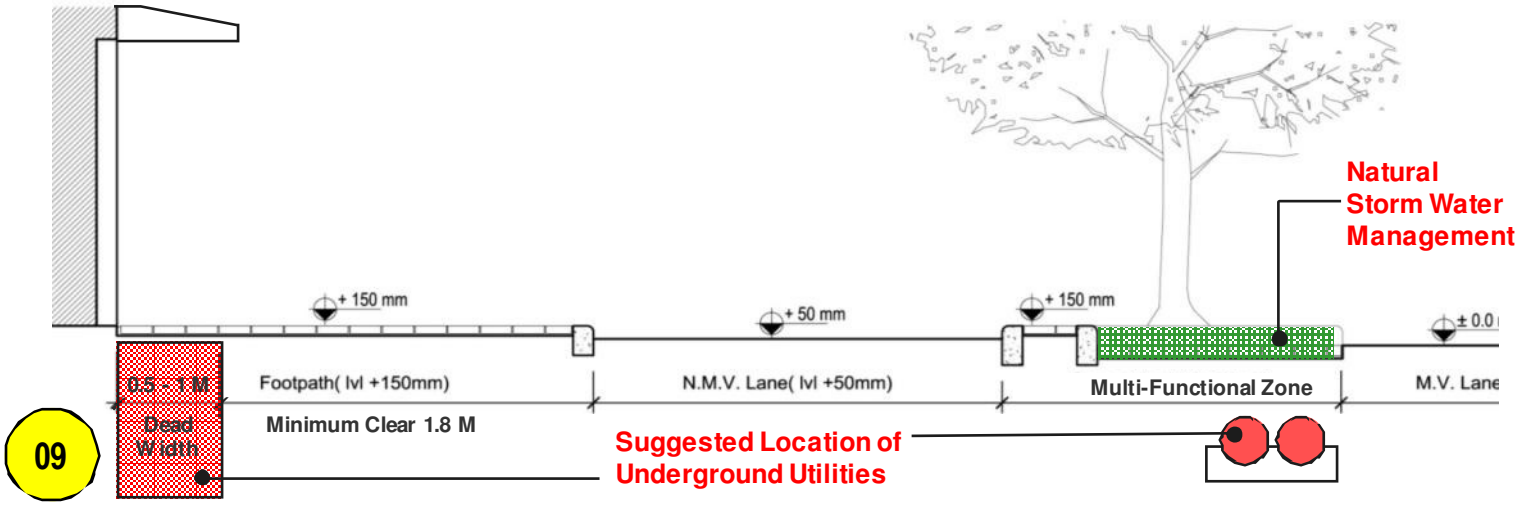
Key Design Guidelines:

- Placement of services which require access covers should **not be done under the NMV lane** as the covers tend to disturb the cyclists ride quality.
- **Indian and international standards are available for spacing between the various services. These should be followed.**
- Locations should be decided after accounting for all the different utilities to be placed in the street. Individual utility providers should get the locations and routes approved.
- Dense urban areas such as Shahjahanabad could consider providing **Common Utility Ducts** for carrying the services. This will prevent periodic digging up of roads for maintenance.
- Utilities must be placed in a neat and tidy manner. Poorly installed services make the city look ugly.
- It would be prudent to **leave pipes under the footpath to provide cabling and services in the future.** This will help avoid unnecessary digging and damage to the pavement and road surfaces.

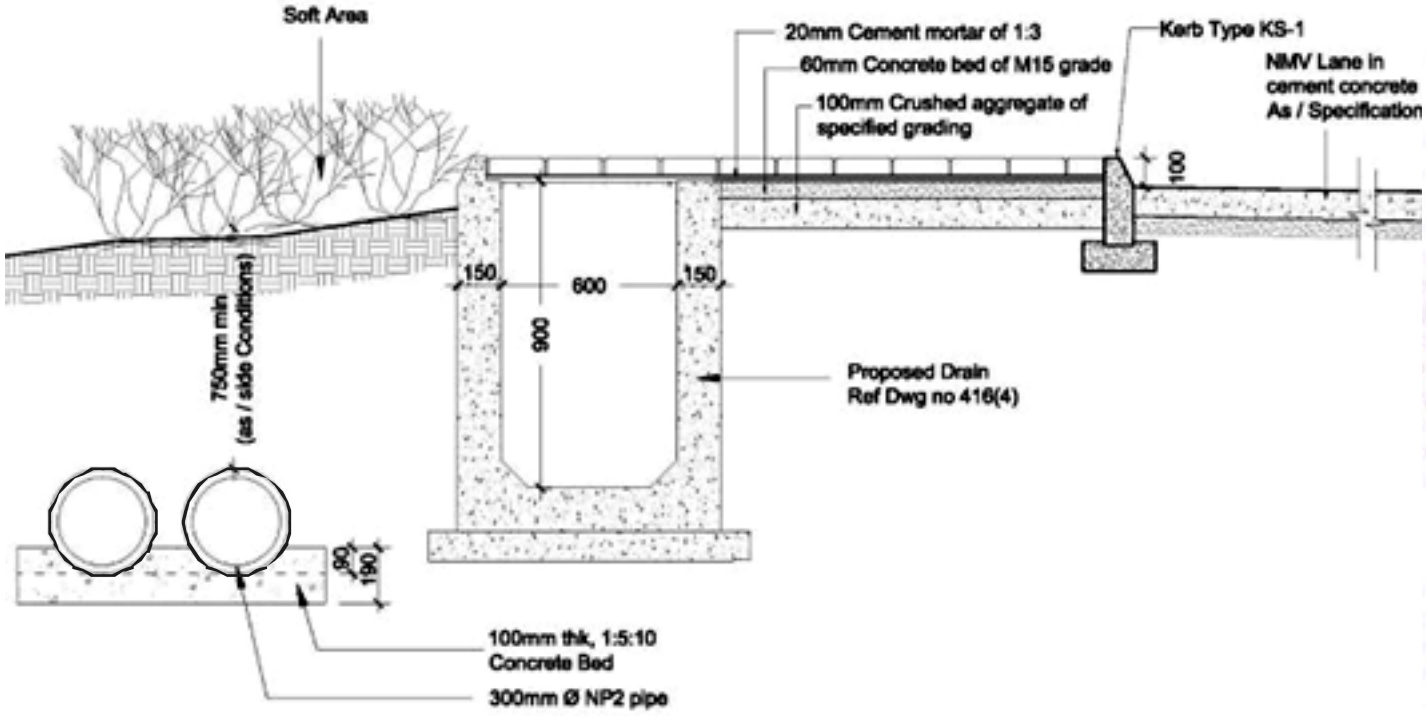
Typical drawings are shown on the following page.



Split Ducts can be used to accommodate existing services during repairs and add future ducts for gradual upgradation.



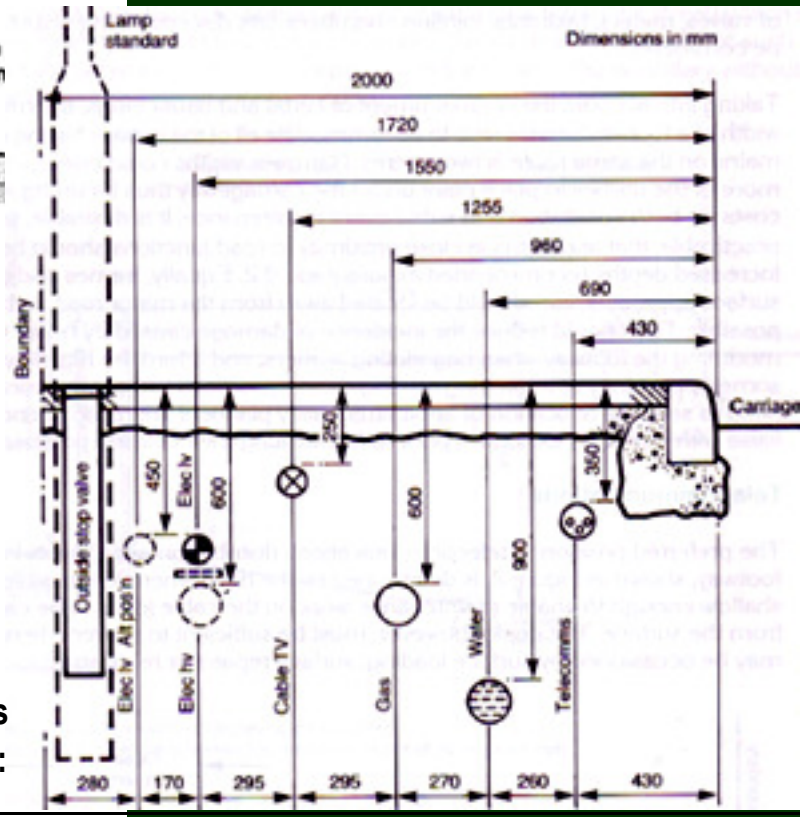
Utilities along the 0.7 M Buffer Zone between Cycle Path and MV Lane, BRT corridor, Delhi.



Sample Underground Cabling Plan

Drawing Courtesy: Pradeep Sachdeva Design Associates

British Services Layout Guideline:



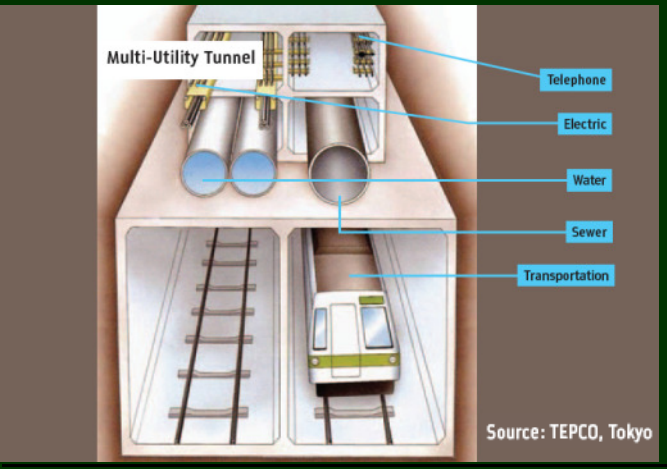
Best Practices

Common Utility Ducts can be integrated with future MRTS (Metro/BRT) projects.

- This will help optimize construction costs and time for provision of future utilities.
- It will allow for planned future redevelopment, densification or new development along MRTS corridors.

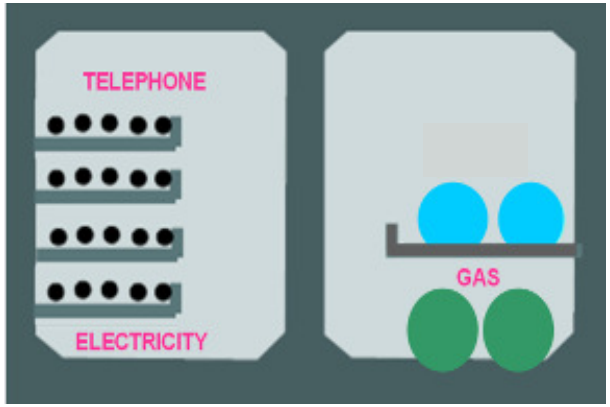
Xinyi and Songshan MRT lines in Taipei, Taiwan, have incorporated common utility ducts into their designs.

*Source: Dept. of Rapid Transit Systems, Taipei



09B Common Utility Duct ("CUD")

A Common Utility Duct (CUD) is a form of structure, above or under ground, which contains more than two types of public utilities, and includes its own drainage, ventilation, lighting, communication, power, monitoring systems, and so on. The advantages of such facility are the reduction of maintenance manholes, accurate positioning of manholes, one-time relocation, and less excavation and repair. It helps keep roads smoother. The set up of common utility ducts will significantly raise the quality of life and reduce social costs.*



Rectangular CUD with or without partition (accessible through Manholes)

Advantages of a CUD:

- Maximum efficiency of underground space usage.
- Decreasing above ground construction that can disrupt traffic; Keeps road/sidewalks Smoother.
- One time relocation and less future excavation and repairs.
- Allow rapid access to all utilities without having to dig access trenches due to confused and often inaccurate utility maps.
- Easy and quick access to utilities after major natural disasters like earthquake etc.
- Public safety & increase the quality of life and reduces social cost.

Limitations of a CUD:

- Extremely expensive. In old/already built-up areas, cost of shifting/relocating Existing Services is huge. However, **huge savings can be made annually on road/pavement resurfacing after utility repairs.**

Sewer/Drainage lines not laid in CUD because:

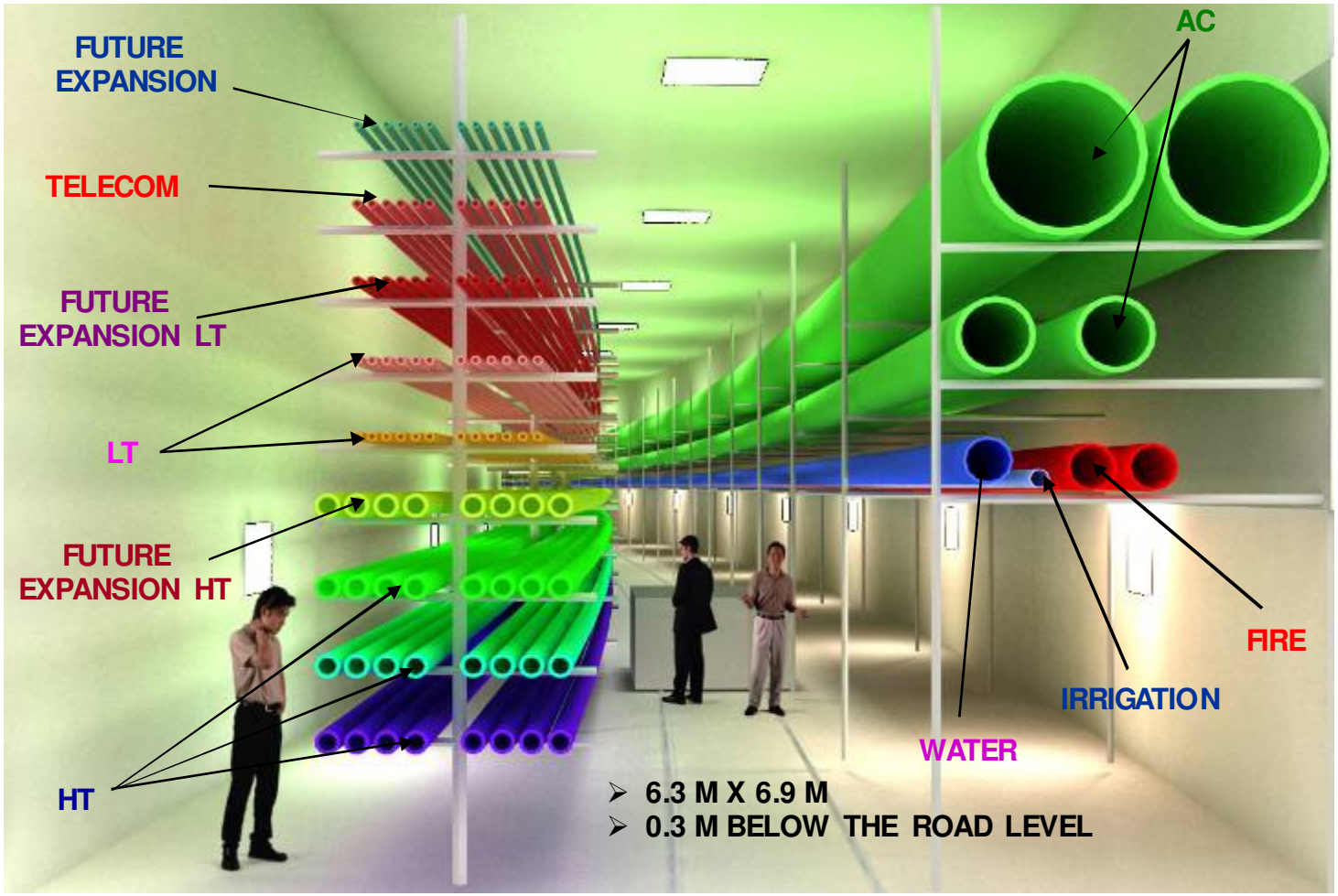
- Sewer/drainage lines run by gravity so cannot be controlled. To control the flow into the main sewer/drain lines large numbers of valves are required, which need heavy maintenance. Other services provided in the corridor can be controlled by main control centre and can be switched off in emergency.
- Leakage in sewer line may lead to foul smell inside the service corridor.
- Size of duct would be much bigger.

Key Design Guidelines:

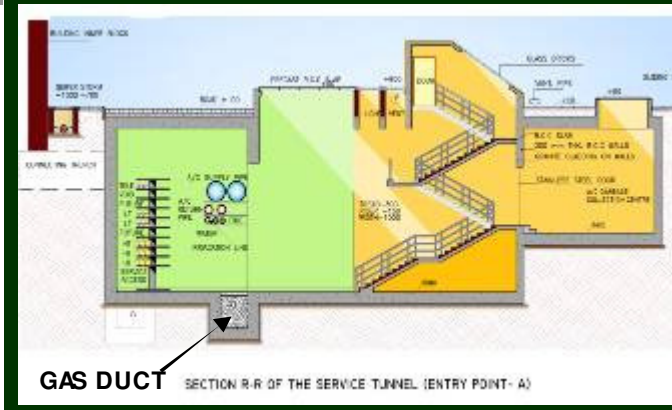
- **Indian and international standards are available for spacing between the various services. These should be followed.**
- Use of cement concrete should be kept to the minimum requirement. Gravel, Sand, soil etc. is preferable as filling.

Guidelines Source: "Common Utility Ducts in NDMC Area", Presentation by NDMC to UTTIPEC and Hon'ble LG in June, 2009

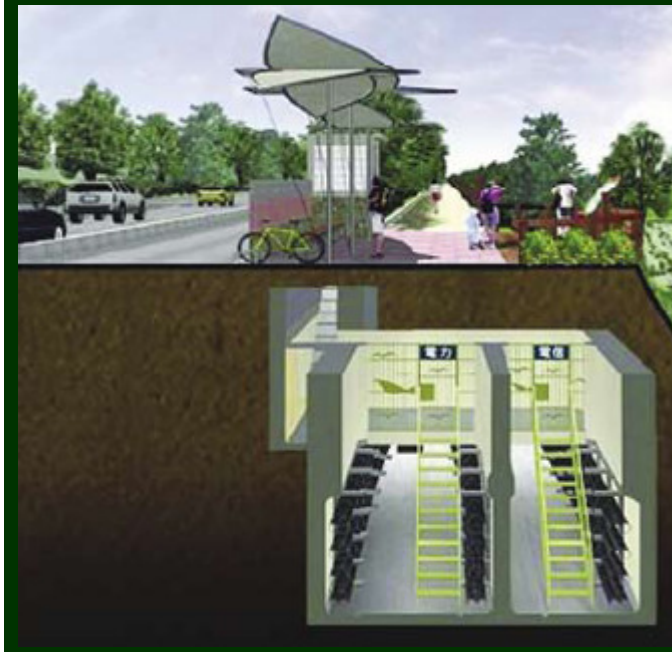
Fully Accessible Duct (accessible through Entrance Chambers)



View of fully accessible CUD proposed in Connaught Place by NDMC, June 2009



Section through Service Tunnel of CUD proposed in Connaught Place by NDMC



Sketch of a Fully accessible CUD with respect to the Street above.

Placement Norms for all 3 Types of CUDs:

- Complete primary & secondary voltage can be laid in u/g duct system.
- Manholes aligned parallel to street to facilitate conduit installation.
- Duct bank straight & should drain into manholes.
- Duct banks to contain pull cords
- Plugged with tapered plastic plugs to prevent entry of debris.
- Diameter of duct pipe : 1.5 x od of cable : 2 x od of gas pipe

Guidelines Source: "Common Utility Ducts in NDMC Area", Report by NDMC to UTTIPEC and Hon'ble LG in June, 2009

Best Practices

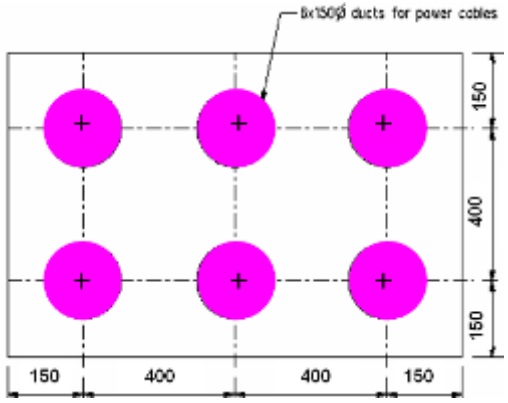
09C Duct Banks

Duct Bank is an assembly of pipes/ conduits which may be encased gravel or soil with intermittent spacers placed over a Concrete Bed, or encased fully in concrete. Ducts banks are placed in excavated trenches which are accessible through manholes provided at required intervals.

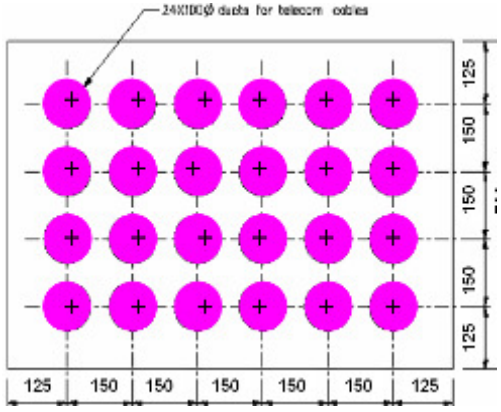
Placement of sewage and water pipes is not preferable within Duct Banks.

Red Danger Tape should be placed at the top of the gravel/ earth filling of the Duct Bank pit in order to warn future excavators of the existence of a Duct Bank below.

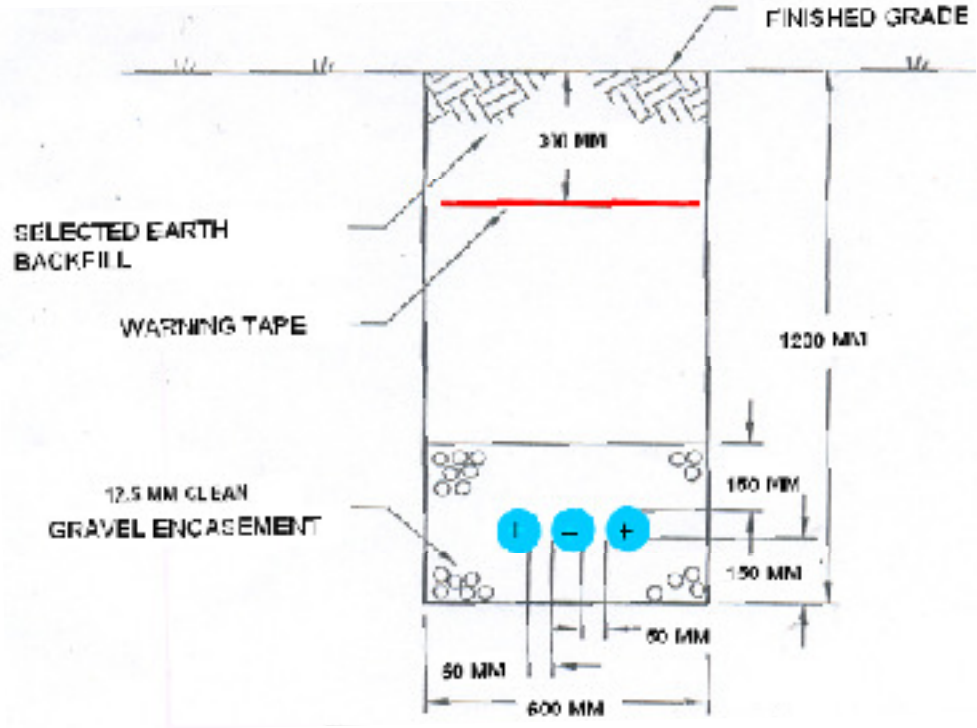
Duct Banks should not be placed in the Multi-functional Zone (MFZ) as tree roots may create interference.



For power cables



For Telecom cables



Above:
Sample Detail of a Gravel encased Duct Bank

Guidelines Source: "Common Utility Ducts in NDMC Area", Report by NDMC to UTTIPEC and Hon'ble LG in June, 2009

10 Public Amenities, Hawker Zones, Signage

10A Local Bus Stop

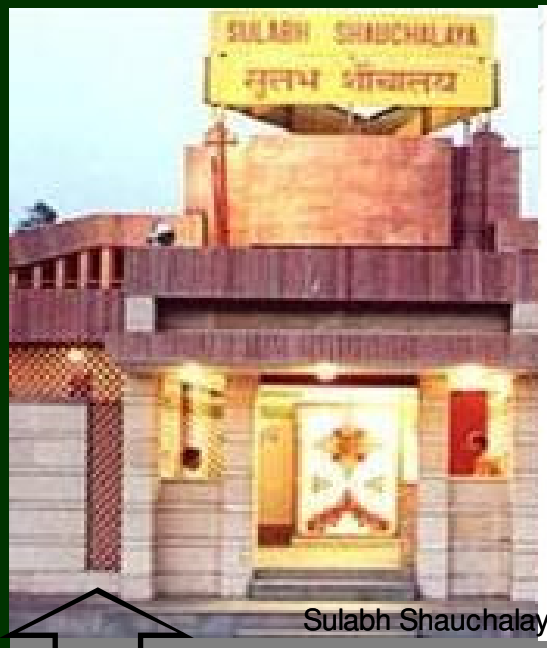
10B Public Toilets

10C Street-Direction Signage

10D Pelican Signals

10E Dustbins

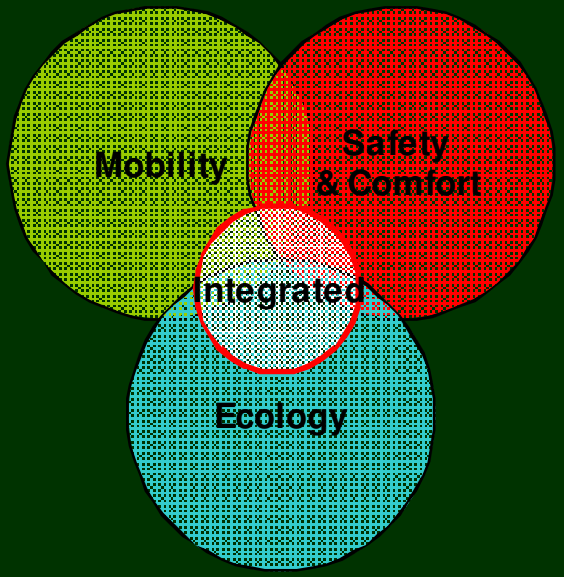
10F Hawker Zones



Sulabh Shauchalaya

Street Names

Hawkers



Streets must accommodate all amenities and facilities needed day to day by pedestrians, cyclists or transit users on Delhi's streets; as well as general Delhi citizens.

In addition, streets are portals for other city level outreach, advertising and public service initiatives that can be provided for citizens with minimal effort…

10 Public Amenities, Hawker Zones, Signage

The Kit of Parts:

Designated Hawker Zones (10G) must be allowed to locate in areas where pedestrians tend to wait or congregate i.e. street intersections and near bus stops or major civic destinations, public offices, etc.

X. **Public Toilets** (10A) should be located near every alternate bus-stop and definitely located at each Rapid Transit Station (Metro/BRT). Frequency of location of toilets should be every ~500 - 800 M.

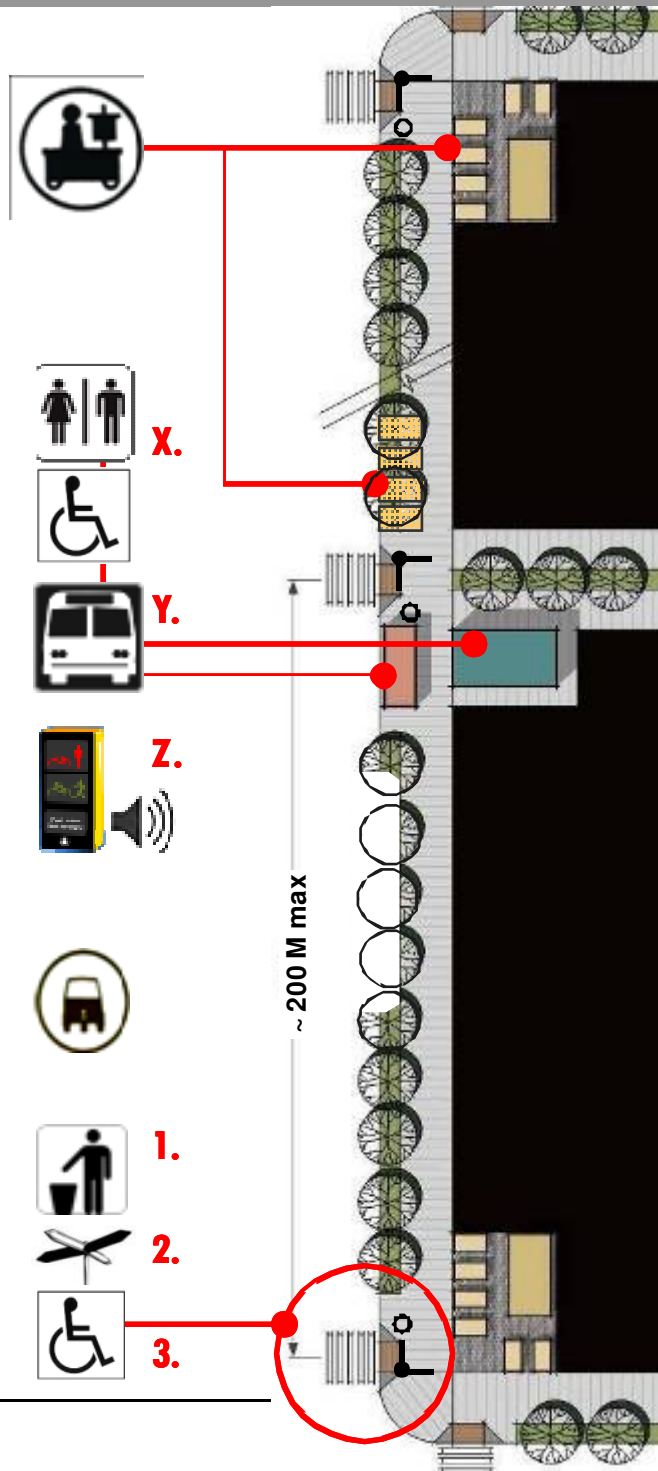
Y. **Bus Stops with Route Maps** (10B) must be universally accessible, and located every ~800-1000 M.

Z. **Auditory Pelican signals** (10C) and raised **table-top crossings** at all mid-block or T-junctions, in absence of a full traffic signal.

Auto and Cycle-Rickshaw Stands (04) should be provided near bus-stops, within the Multi-Functional Zone.

"Set of 3" at every intersection must be provided for **Pedestrian Way-finding**:

1. - Dustbin with map (10E)
2. - Street directional signage (10D)
3. - Universal accessibility features (03B)



10A Local Bus Stop

Key Principles:

- Dustbins – their frequent provision, cleaning and maintenance are key aspects to the cleanliness of a city.
- **All bus stops must be universally accessible.**
- Bus Stops should preferably be located within the **Multi-Functional Zone** – so that they do not interfere with the **1.8 M clear walking zone** for passing pedestrians at the back.
- **Criteria for Placement of Local Bus Stops:**

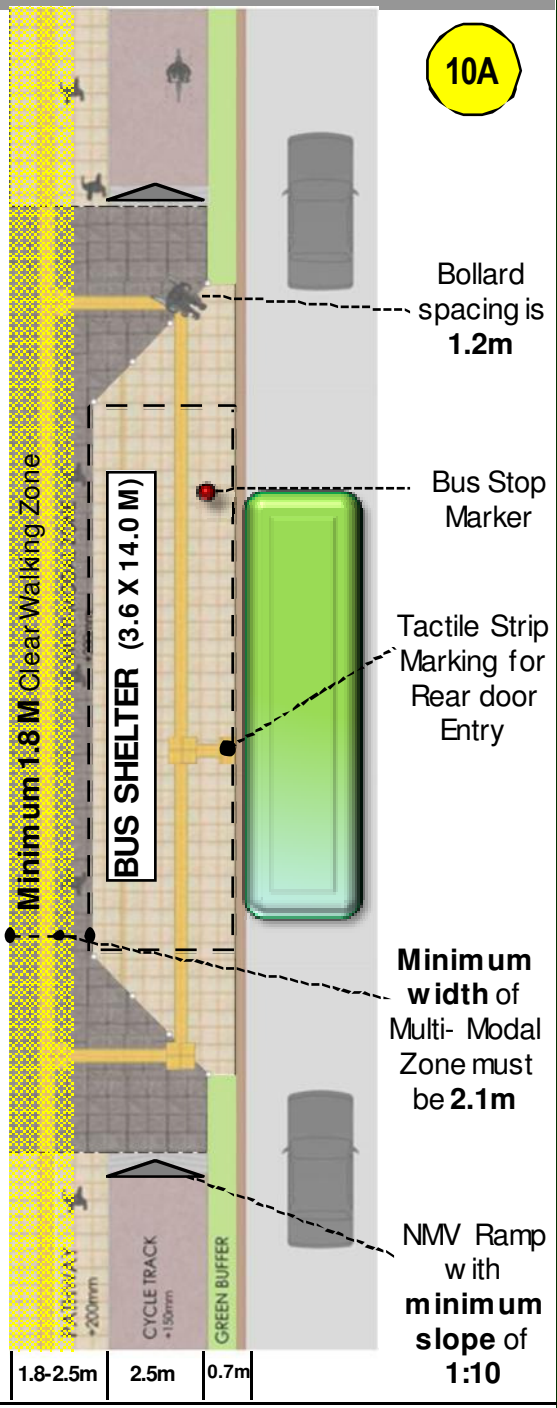
Placement of Stop
- Convenient location to major land uses (pedestrian generators)
- Convenient to transfer movement

Pedestrian Access
- Route to be direct as possible, integrating short-cuts
- Connecting path should be clear of obstructions, firm surface material, well drained
- Consider impact of stops on adjacent properties
- Adjacent, or as close as possible to stop going in the opposite direction
- Accessible stops should have matching adjacent stops
- Convenient for errand running and "trip linking" tasks
- Grade of road should not impede accessibility

Visibility
- Drivers' sightlines should not be obscured by trees, shrubs, poles, buildings
- Where there are bike lanes: locate sufficient distance for cyclists to stop safely
- Buses should not restrict visibility of traffic signals
- Do not place on curves
  - 160 m. sightlines going into zone and coming out of zone
- Ensure clear sightlines on the right side of the bus - no obstructions
- Stop should be well lit

Proximity to Crosswalks
- Intersection stops: if near side is necessary, ensure 4.5 metres distance
- Mid block stops: always locate stop on far side of crosswalk so that pedestrians cross from behind the bus not in front
  - Avoid locating stop close to driveways especially those with high traffic volumes

Driveways
- If impractical, ensure full visibility for vehicles exiting driveways
  - Place on far side of driveway (sight distance for left turning still a problem)
- Consider volumes and turning movements of other vehicles



*Source: UTTIPEC

This Bus Stop is accessible, but Clear 1.8M Pedestrian Zone has not been left. Moreover, Space in front of bus stop for waiting passengers is highly inadequate.

This Bus Stop is correctly placed.

A Local Area Map or an entire **Bus-Route Map** should be displayed on the panels of all bus-stops (besides advertising), to help Wayfinding.

Not Preferable

Lack of adequate clean and frequent public toilets and abundance of unwatched boundary walls makes Delhi's public spaces an open public toilet.

10B Public Toilets

Key Guidelines:

- **Provide public toilets at a distance of every 500 – 800 M** (5-8 minute walk) from each other and from any destination.
- Toilets should be located near **every alternate bus-stop** and **at each Rapid Transit Station** (Metro/BRT)
- Public toilets should be provided as combination of general toilets and accessible toilet, where accessible toilet to be marked as Multi-use toilet to be used by senior citizens, families with young children and disabled persons.
- **Environmental friendly *Sulabh Shauchalayas*** should be built as public toilets as they have the following **advantages:**
  - They do not smell
  - They consume very little water and are easy to clean and maintain (in contrast to conventional toilets that require a minimum of 10 litres.)
  - They have potential to tie up with other community based environmental technologies such as biogas production, etc. for heating, cooking, and generating electricity.
  - They provide new employment opportunities for many.
  - Environmentally balanced wastewater treatment based on a duckweed and fish raising (pisciculture) ecosystem that provides economic opportunities for the urban poor.

(Above) **Sulabh Shauchalayas**

(Right) **A public toilet system that incorporates local treatment and water recycling system – providing much needed water for horticulture.**

Source: Pradeep Sachdeva Design Associates, 2009

Not Preferable

Obscure Street Signage…..

10C Street-Direction Signage

Key Principles:

Signage for Wayfinding and Information of Pedestrians and Cyclists are essential for creating a public transport friendly city.

Signage provides help to pedestrians to navigate the city w ith ease and safety, and have the follow ing functions:*

- **Orientation – Way finding** (Street Signs)
- **Availability of Public Transit nearby** (Transit Signs)
- **Guiding Street Flow** (Traffic Signs)
- **Announcing about City's specific features or attractions** (Information Signs)
- **Conveniences** (Toilet, dustbin, haw ker signs).

- Signs should reinforce the overall character of the specific district and be consistent throughout the City.
- Posts and poles should be arranged to minimize the number and avoid clutter.

Pleasing Signage Palette above. But Non-Vector Signage is ineffective for Wayfinding.

Visual Signage is preferable for Amenities and General Information

*Source: San Francisco Better Streets Plan

Best Practices

Vector Signage is Essential for Wayfinding.

Not Preferable

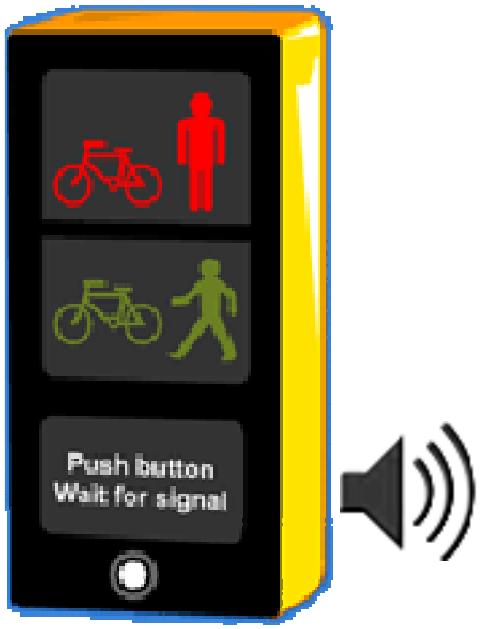
Delhi has very large block sizes. This provides limited permeability for pedestrians and makes them difficult to easily reach Destinations on the opposite side of the street after alighting from a bus or train... thus forcing them to jaywalk and risk their lives.

At the same time, aggressive Delhi drivers do not stop at designated pedestrian priority STOP signs, unless it is a signalized intersection...

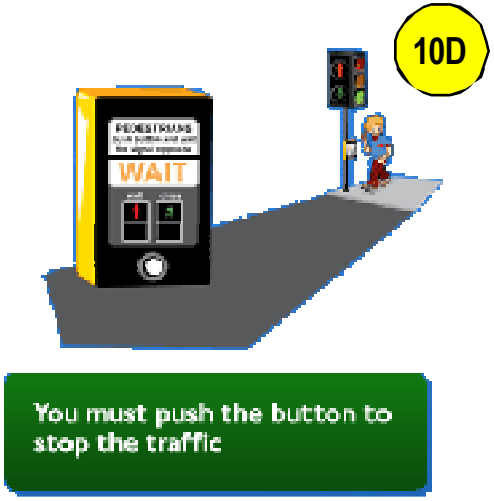
10D Pelican Crossings

Key Principles:

- Pedestrian initiated traffic lights maybe installed at mid-block crossings to make traffic stop for pedestrians, cyclists and the physically handicapped.



Auditory Pelican Signal



How to Use a Pelican Crossing? – A Road Safety Education Feature on the Northern Ireland Road Safety Website. Source: http://www.roadsafetyni.gov.uk/

See Also:

03B	Raised Table-Top Crossings
06B	Mid-Block Crossing

*Source: UK Government Road Safety Websites

Not Preferable

Littering in Delhi is a perennial problem.
Source: Hindustan Times, Oct 2009

"How to use" Delhi's new 'source separated' dustbins is a mystery to most people in the city.

10E Dustbins

Key Principles:

- Dustbins – their frequent provision, cleaning and maintenance are key aspects to the cleanliness of a city.
- **Dustbins must be provided at each bus-stop and street intersection** in order to discourage people from throwing trash on the road.

Key Concepts:

- On Source Separated Dustbins – **signage for "Trash type" should be made of graphic symbols** – so that even illiterate people can understand how to use them.
- **Private Sector could be involved in manufacturing and maintenance of dustbins** in return for the incentive of getting waste for recycling or tax subsidies for firms if conducted as a CSR initiative.

"Graphically explained" Source Separated Dustbins: Shanghai.

*Graphics Source: Miscellaneous, representative only.

Best Practices

Transparent dustbins can be used in crowded places like Metro Stations, etc.

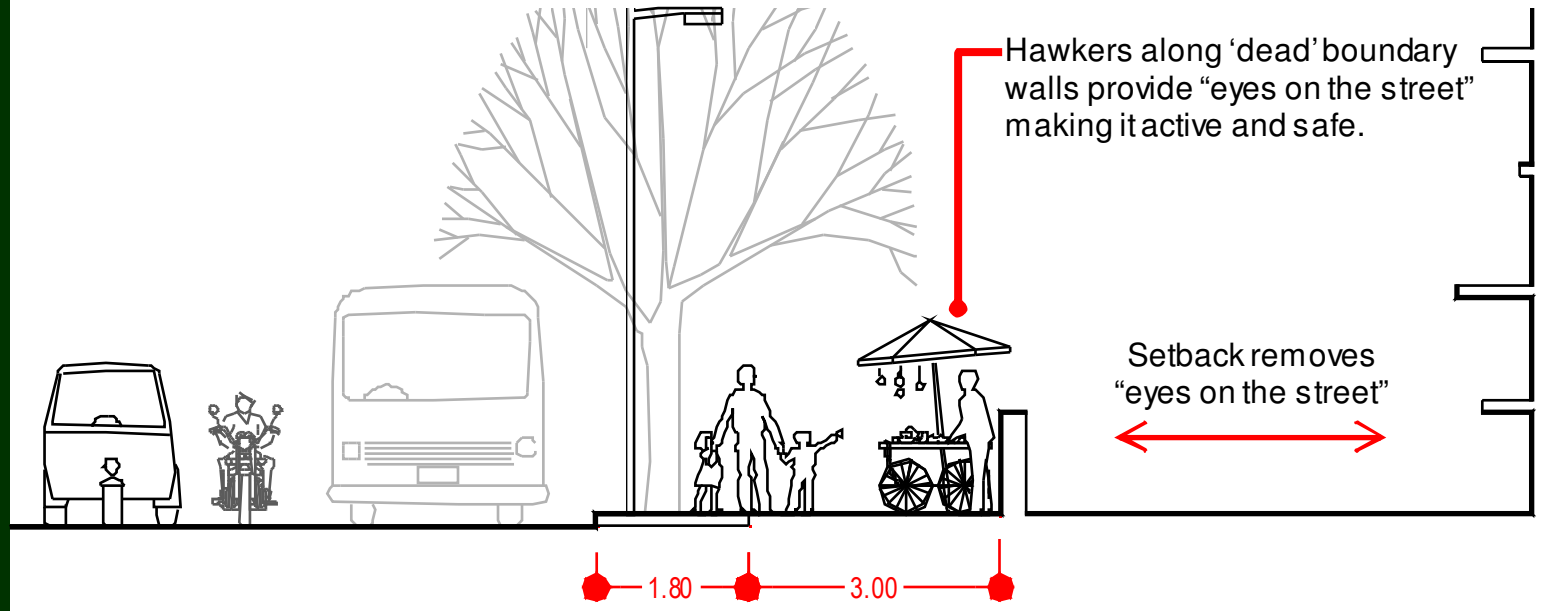
Opaque Dustbins with Maps - can be use at general Street corners and Intersections.

Not Preferable

Hawkers must be given designated space within the road Right-of-Way, so that they don't occupy the Minimum Clear 1.8 M Pedestrian Walking Zone.

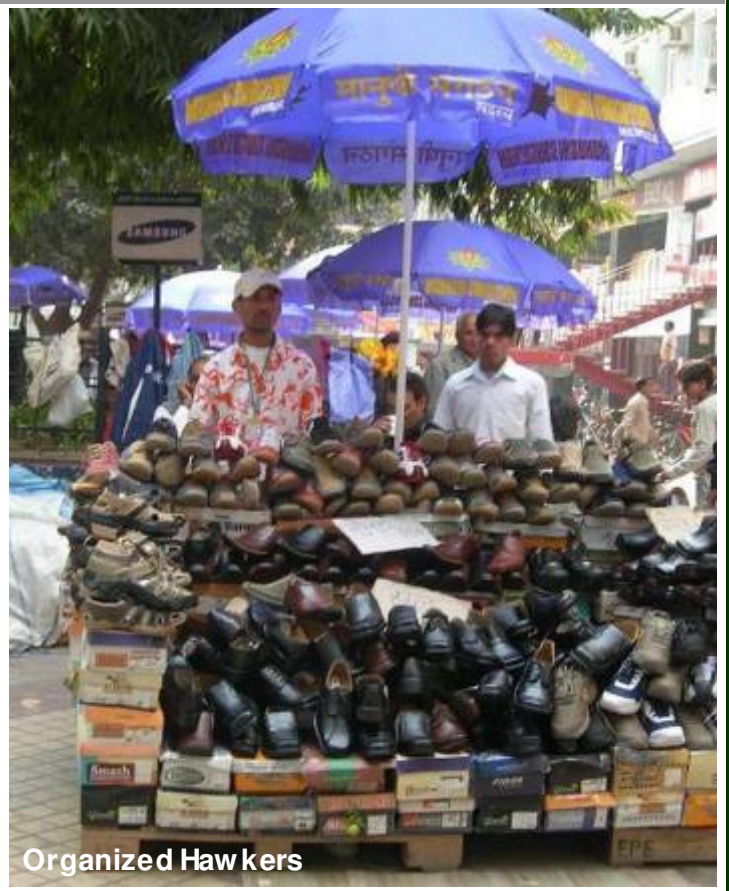
10F Designated Hawker Zones

Hawkers or "micro-entrepreneurs" provide a wide variety of services and amenities to people, at convenient locations – with negligible investment and infrastructural costs.



Benefits of Hawkers in Street-space:

- They keep streets busy, vibrant and safe.
- They provide a variety of cheaper food and retail options.
- They infuse mixed-use and encourage walk-trips in a city planned predominantly based on private-vehicle use.
- They generate self-employment for a large number of people.


Organized Hawkers


Organized Food Stalls, China


Organized Food Stalls, Beijing


Organized Food Hawking


Organized Hawking, London


Organized Hawking, Mumbai

Pictures courtesy Pradeep Sachdeva Design Associates

Best Practices

Connaught Place, New Delhi

Fashion Street, Mumbai

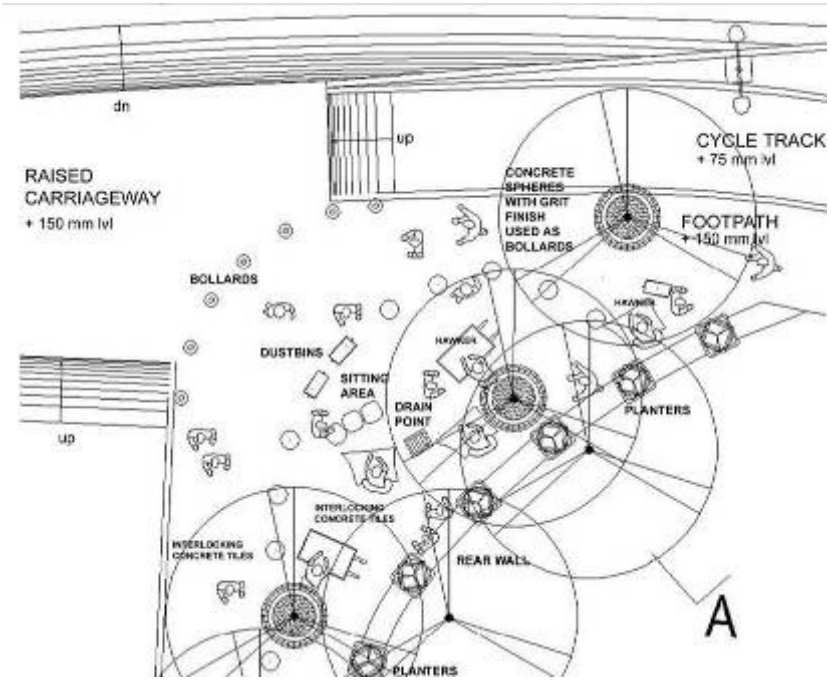
Hawkers must be given designated space within the road Right-of-Way, so that they don't occupy the Minimum Clear 1.8 M Pedestrian Walking Zone.

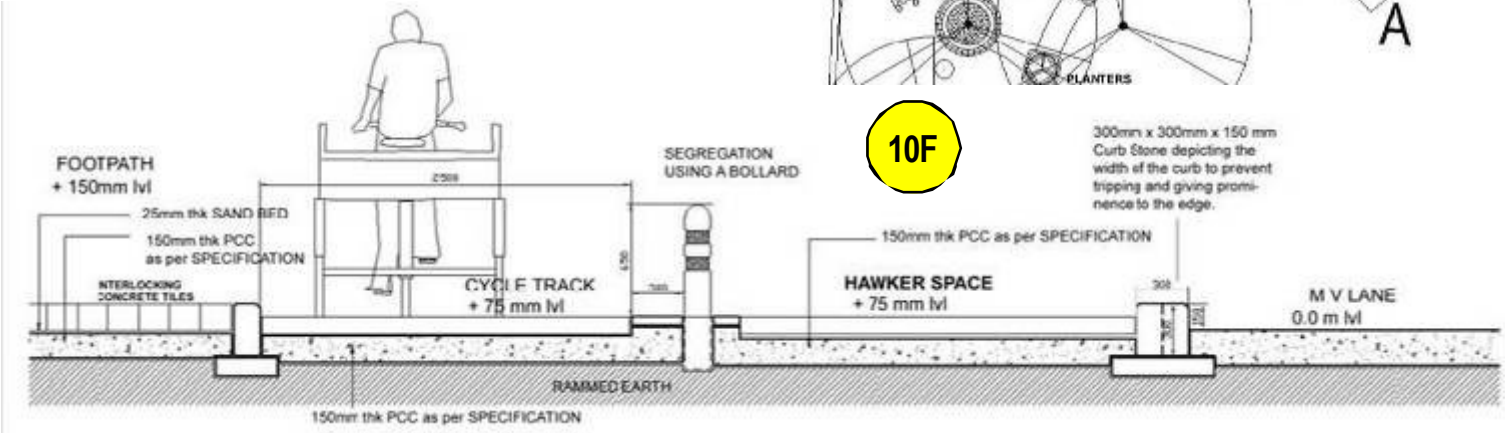
10F Designated Hawker Zones

Designated spaces will make enforcement easier which has not been possible so far.

Key Principles:

1. **Hawkers MUST be accommodated within the Road RoW – approximately every 500-1000 M** on a public street.
2. They are needed at all commercial centers and must be at walking distance from offices, homes and retail areas.
3. Flexible Hawking Zones can be accommodated within the Multi-Functional Zone described in Section 04.
4. Essential Utilities also must be provided as outlined in the **NATIONAL POLICY FOR URBAN STREET VENDORS:**
   a) Provide provisions for solid waste disposal
   b) Public toilets to maintain cleanliness.
   c) Aesthetic design of mobile stalls/ push carts
   d) Provision for electricity
   e) Provision for drinking water
   f) Provision for protective covers to protect their wares as well as themselves from heat, rain, dust etc.
   g) Storage facilities including cold storage.





*Source: BRT Corridor Design Summary, TRIPP

10F Designated Hawker Zones


San Diego

New Market, Kolkata

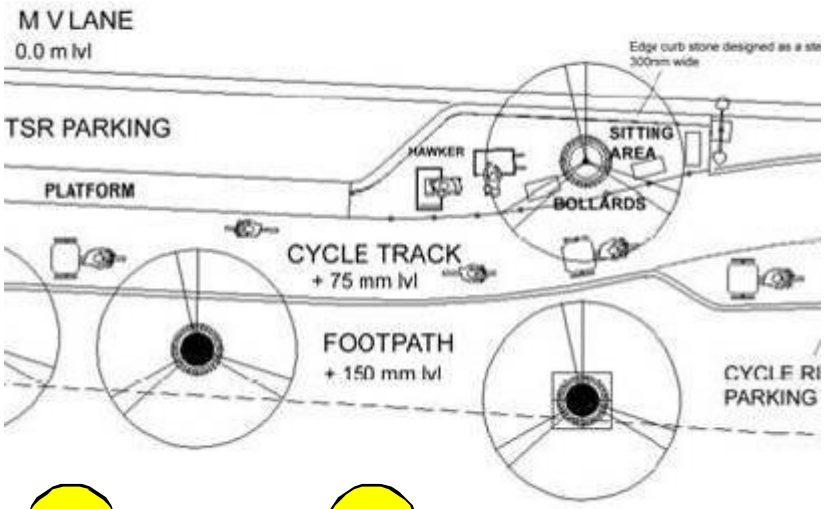
A

Hawker zones at Street Intersections

1.8 M clearance for moving pedestrians

B

Hawkers fronting Shops




CP, Delhi

C

1.8 M CLEAR Walking Zone

Hawker zone on pavements

10F **See Also:** 04

Best Practices


In Columbia


In Beijing


In New York

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6. Design Toolkit:
Additional Components

11 Traffic Calming Measures

11A = See 01D Kerb Radius and Slip Road Treatment

11B = See 03B Raised Table-Top Crossings and Driveways

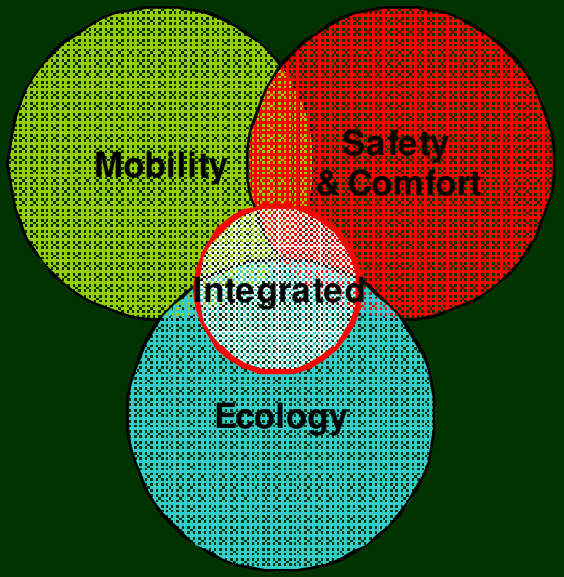
11C Paving Variations at Crossings, Stop Signs, Intersections

11D Pedestrian Dominated "Kerbless" Streets

11E Chicanes

11F Mini Traffic Calming Circles

11G Full Closures

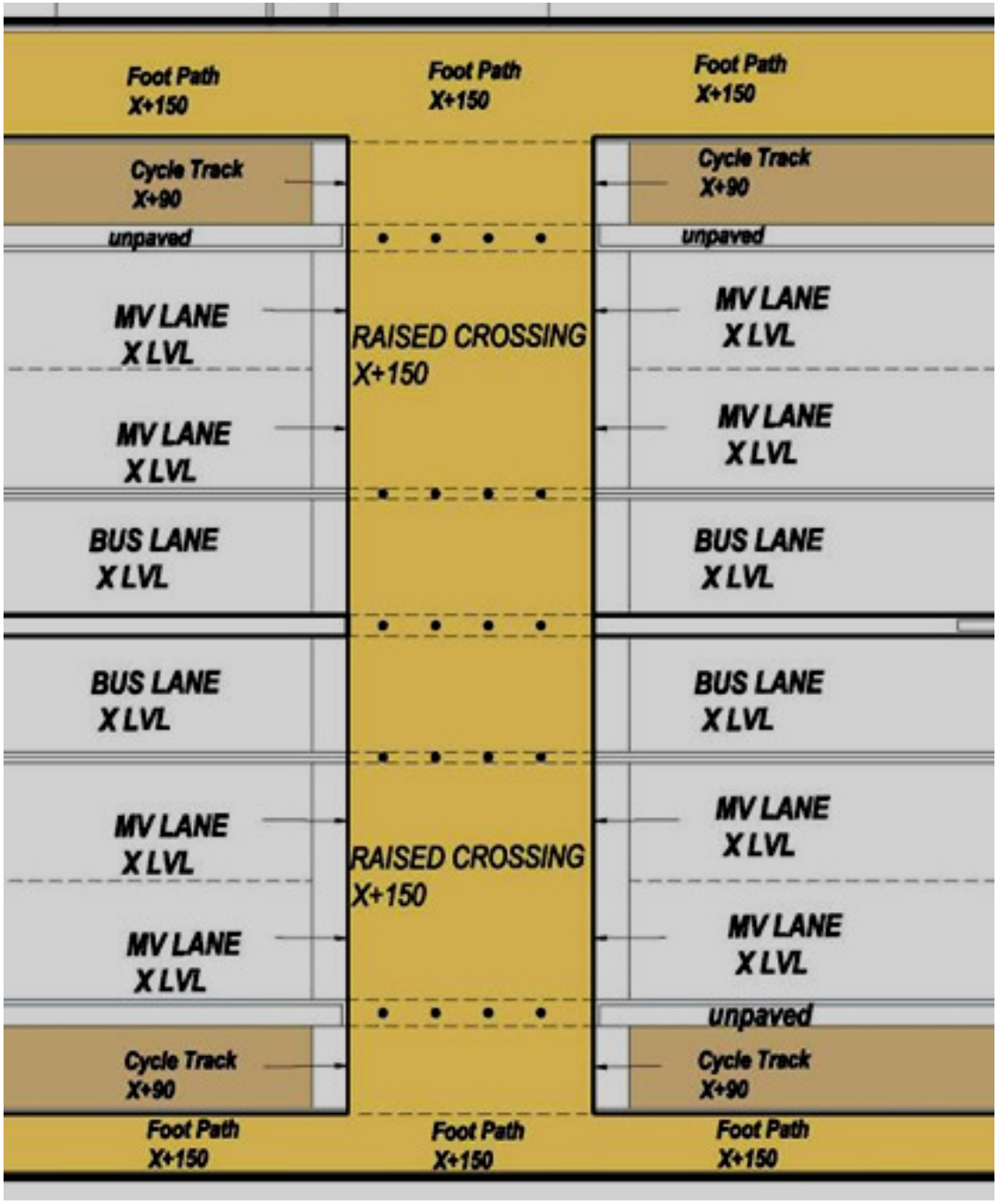


Traffic Calming is the management of traffic – through a combination of Education, Enforcement and Engineering devices – so that its negative impacts on residents, pedestrians and schools is minimized.

The goal of traffic calming is to reduce vehicle speeds, improve pedestrian and cyclist safety, and enhance quality of life.

Signal free and fast movement of motorized vehicles *within city limits* (other than Mass Rapid Transit Systems) is to be minimized, as this makes the city extremely unsafe for pedestrians and public transport users and causes fatal accidents.

11B = See 03B Raised Table-Top Crossings & Driveways



Only Anti-Skid, uniform materials to be used on Tabletop Crossings – for comfortable access by people with reduced mobility.

www.pedcycleimages.org

See also: 03B 06C

Table-top Crossings slow down traffic at Intersections and Mid-block Crossings – allowing pedestrians & cyclists to cross safely

Drawing Courtesy: TRIPP and SG Architects, 2009

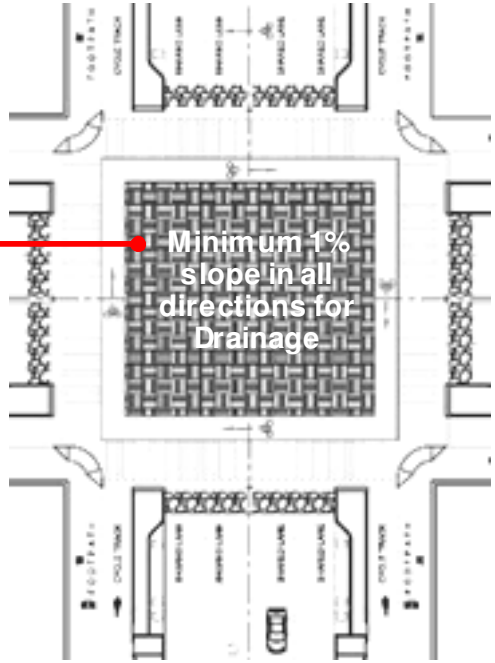
Best Practices

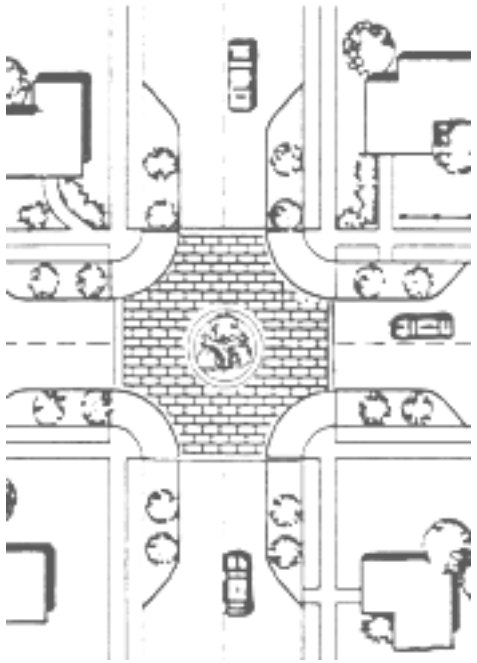
11C Paving Variations at Crossings, Stop Signs, Intersections

Raised Paved Intersections

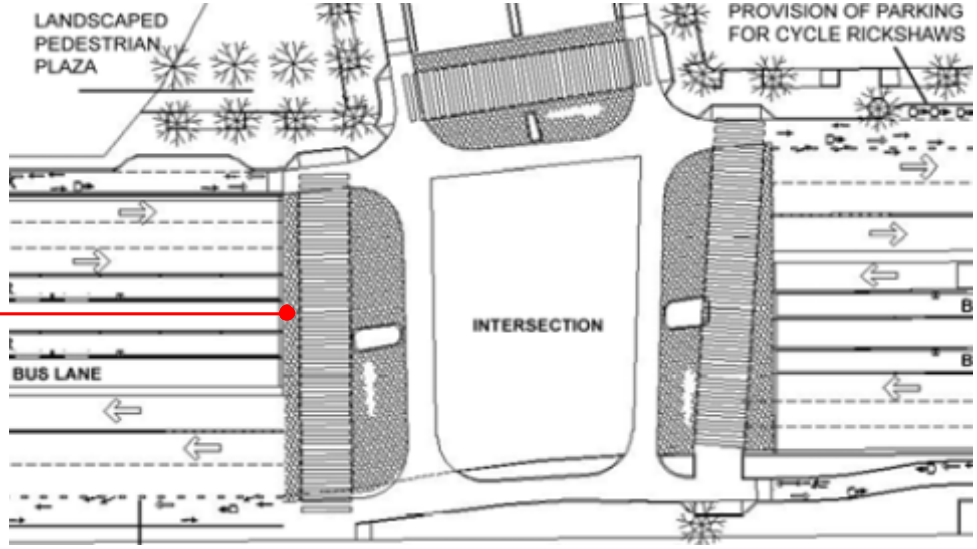
Paving change before Tabletop Crossing

Paving change before normal Zebra Crossing



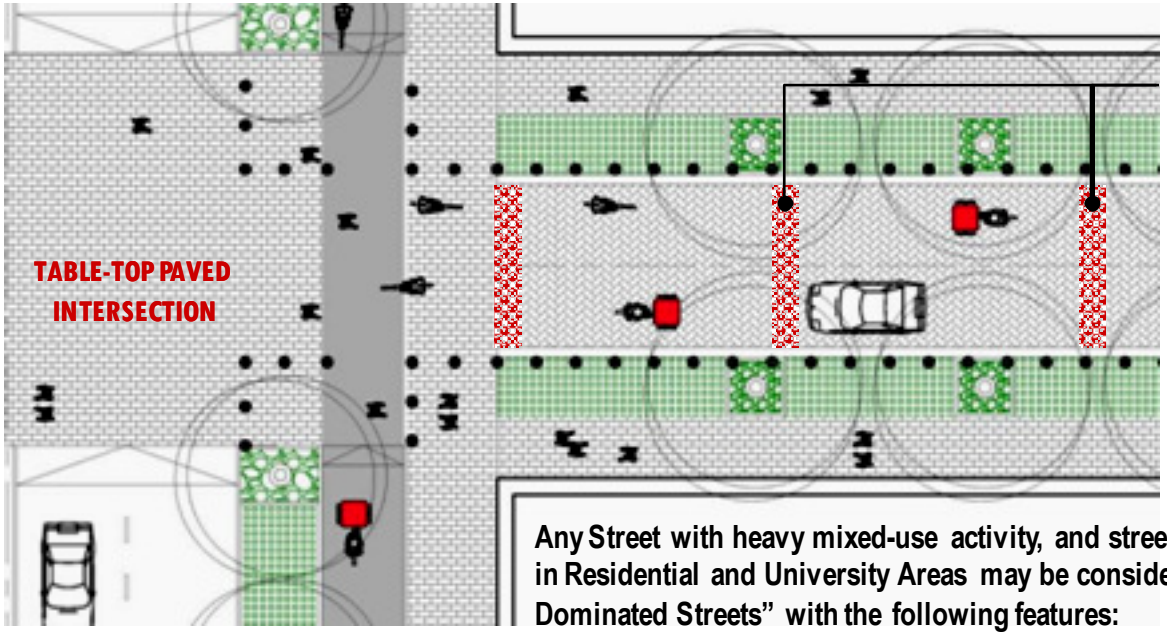


Raised or Paved Plazas (or "Chowks") at Intersections induce traffic to slow down while turning – making them watch out for crossing pedestrians and cyclists at the intersection.



Use of continuous Paving Materials or Colors at Crossings – provides visual continuity to Pedestrians and also makes crossings clearly visible to drivers from a distance.

11D Pedestrian Dominated: Kerb-less Streets



Rough Textured Paving Change at regular intervals can help keep MV speeds under acceptable limits.

SHARED "CARRAIGEWAY"

PERMEABLE PAVING along " TREE PLANTING ZONE"

"WALK ONLY ZONE"

Any Street with heavy mixed-use activity, and streets narrower than 12 M in Residential and University Areas may be considered "Pedestrian Dominated Streets" with the following features:

- These streets can be made "Kerbless" and **paved over in different Materials** to give the impression of being slow -speed and pedestrian dominated.
- **Paving along the main carriageway** helps create friction, making motorized vehicles move slow er, thus increasing safety. Safe jayw alking is desirable on such streets.
- **Bollards and/or Tree Buffers** may be used to keep cars from entering the "Walk Only Zone" along the edges of the Street.


Kerbless Street with Bollards, Montmartre Paris

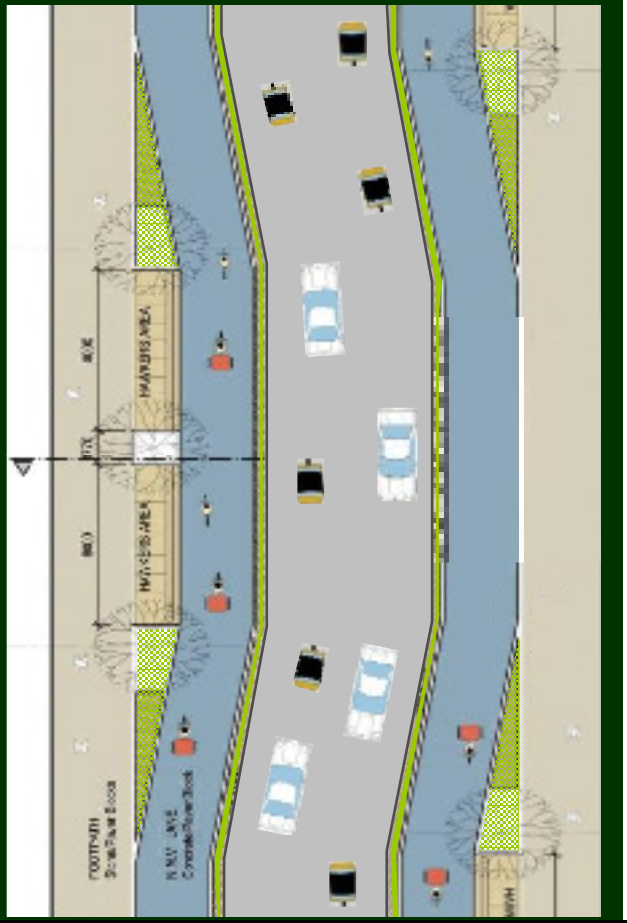

Kerbless Street, Soho, London

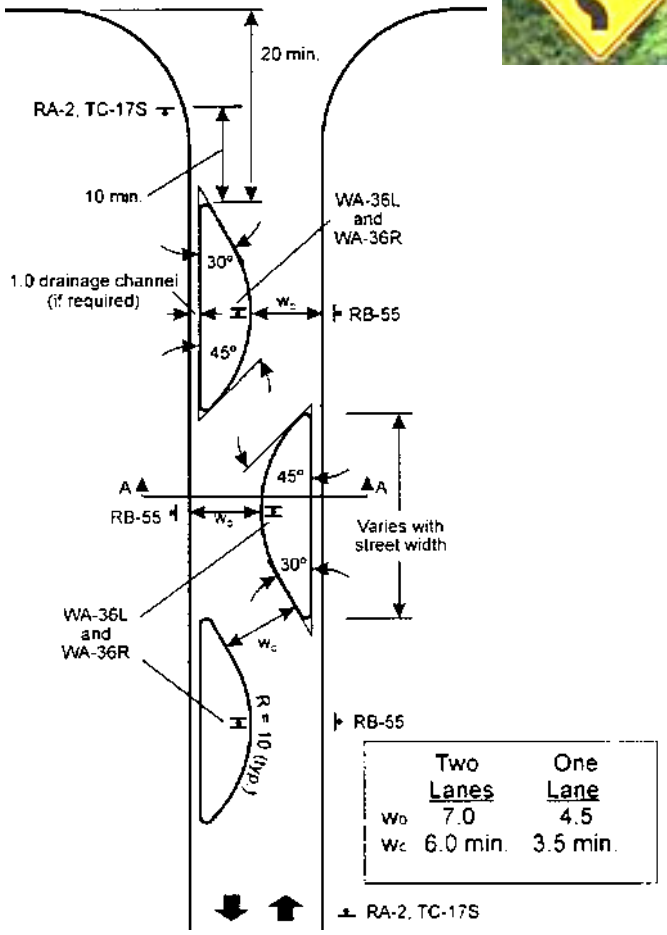

Kerbless Paved Streets, Mumbai

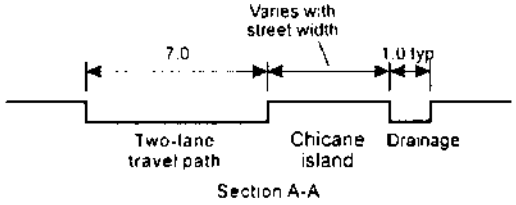

Kerbless Street with Bollards, Brick Lane, London

11E Chicanes

Chicane: Vancouver, Canada (Crédit: Richard Drdul)







Sign Descriptions:

RA-2	Yield
RB-55	Stopping Prohibited
TC-17S	Yield to Oncoming Traffic
WA-36	Object Marker

- The travel path through the chicane can be one lane or two lanes as noted.
- Spacing of chicane segments dependent on site considerations, e.g. driveway locations
- Island plantings should not obscure driver's view of chicane traffic.
- Additional RB-55 signs may be required to satisfy local convention.
- Bicycles are to use the same path as motor vehicles, not the drainage channel.
- Depending on local climate and preference, vertical delineation other than Object Markers (WA-36) may be more appropriate. Possible alternatives include bollards. Delineation Markers (WA-37), landscaping and curb painting.

A chicane is a series of alternating mid-block kerb extensions or islands that narrow the roadway and require vehicles to follow a curving, Serpentine path – thus reducing vehicular speeds and increasing safety for pedestrians and NMVs.

Chicanes can be used on one-way or two-way streets and can be single lane or two-lane configurations.

Key Guidelines:

1. Chicanes can be created by modulating the "Multi Functional (Tree Planting) Zone in order to created the curved geometry. (See also: Section 04)
2. Chicanes must maintain the required clearances for emergency vehicle access.
3. Locate trees and planting (06C) within Chicane kerb extensions to capture and filter storm water, and add greenery to street.
4. Integration with Street Storm Water management plan is a must, as gutters may have to be incorporated in Chicane Design.

Source: Draft *Canadian Guide to Neighbourhood Traffic Calming*, 1998, Copyright Transportation Association of Canada.

11F Mini Traffic Calming Circles

A Mini- Traffic Calming Circle is a raised island located in the center of an intersection around which traffic must circulate.

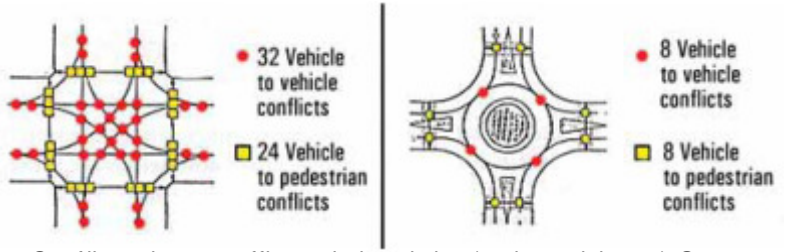
They are ideal for all Streets below the Hierarchy of Primary Collector (30-40 M or lower) where Design Speeds are to be kept below 30 km/hr for safety of all road users.

Key Guidelines:

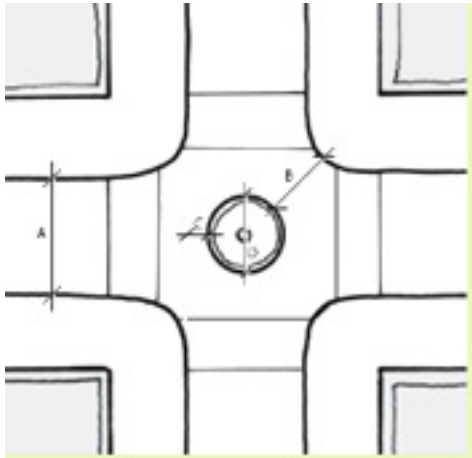
1. Mini traffic circles should be large enough to force cars to slow down to go around them; but the outer two feet or so of the circles should have a concrete apron, with a low four-inch kerb such that emergency vehicles can go over easily when necessary. Typical Design speeds for movement around the circle should be 10 to 15 mph; exit speeds should be limited to 15 mph through the circle's design wherever possible.
2. Centres of mini traffic circles should be attractively landscaped. Planting of local, drought-tolerant and low-maintenance plants is encouraged. Local community participation should be sought in planting and maintaining of these circles.

Advantages:

- Reduces speeds and accident rates, particularly when applied consistently to an area.
- Can green and beautify the streetscape with trees and/or vegetation, improving environmental quality.
- Rain gardens and local planting in traffic circle can provide Stormwater treatment and reduce run-off, seasonal flooding and pressure on existing stormwater infrastructure.



Conflict points at traffic calming circles (and roundabouts). Source: Stidger, Ruth "Can America Handle Roundabouts," Better Roads, 2003



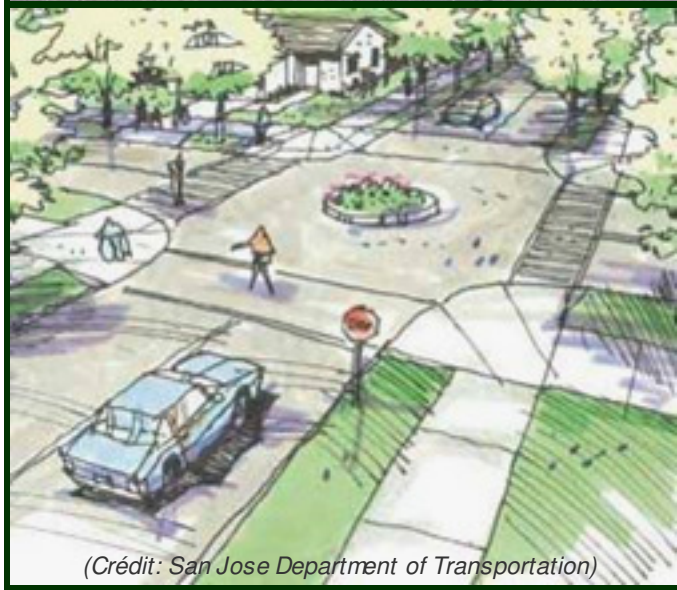
OPTIMAL DIMENSIONS	
Offset Distance	Opening Width
5.5' (max)	16' (min)
5.0'	17' (~)
4.5'	18' (~)
4.0'	19' (~)
3.5' or less	20' (~)

A - Street Width: Existing
B - Opening Width: Typically 16-20 feet
C - Offset Distance: 5.5 feet max (varies)
D - Diameter: Typically 12-20 feet

Source: San Francisco Better Streets Plan

Best Practices

Mini Traffic Circle in Vancouver, Canada
(Crédit: Richard Drdul)



(Crédit: San Jose Department of Transportation)

Mini Traffic Calming circles should not be confused with **Full Roundabouts,** which handle much higher traffic volumes and encourage free flowing, faster movement of motor vehicles, thus making intersections less safe for pedestrians.

Full Roundabouts are NOT RECOMMENDED, unless necessary for handling 5 or 6-arm road intersections.

11G Full Closures

Full Closure in Residential colony: Vancouver, Canada
(Crédit: Richard Drdul)

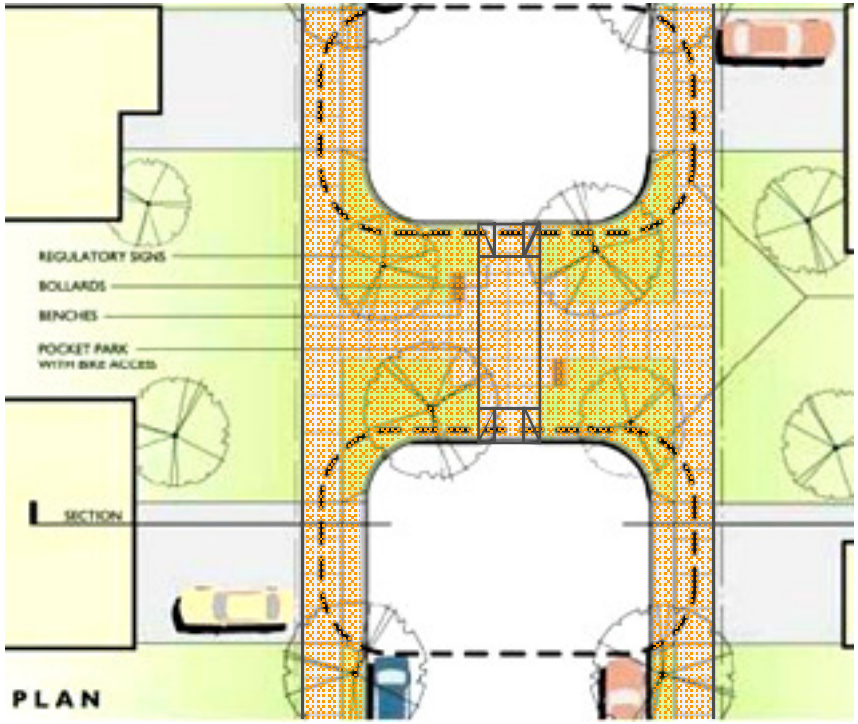
Full Closure in a Mixed Use District: London

Full Closure is a a physical barrier at an intersection to fully close a street segment to motor vehicle access at one end.

- The barrier can be a fence or bollards, a basic sidewalk, or an elaborate landscaped space or plaza.
- The affected street segment becomes a cul–de–sac for motor vehicles, while pedestrian and bicycle access can be maintained through the use of a dedicated bicycle channel or other design elements.
- Emergency vehicle access can be maintained by using mountable kerbs and a clear path.

Key Benefits:

1. Speeding through traffic is completely eliminated, limiting street access to only local residents/users. **Permeability to pedestrians and NMVs is maintained, ensuring easy shortcuts for these users.**
2. Pedestrian and NMV safety is enhanced by eliminating vehicular crossing at the closure.
3. Larger closures can create a sizeable public spaces with community facilities such as seating, plantings, etc.



Drawings Courtesy : City of San Jose: Traffic Calming Toolkit (2001)

12 Material Selection

12A Material Selection Guidelines

12B Sustainable/"Green" Material Options

- Concrete with Cement Substitutes
- Clay Substituted: Fly-Ash Bricks
- Recycled Asphalt
- Recycled Rubber Pavement

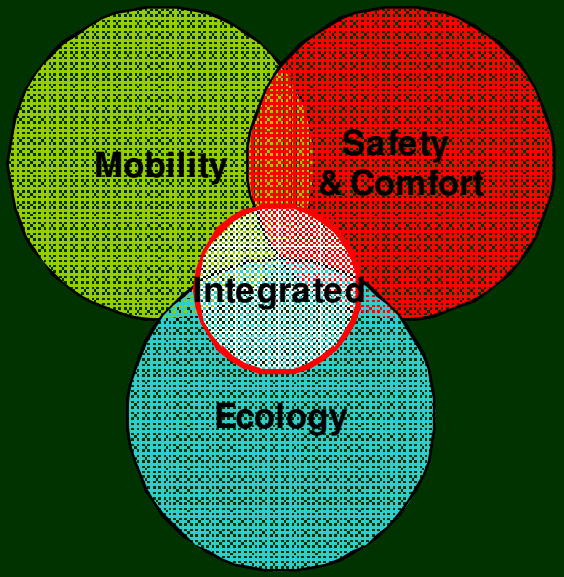
12C High-Albedo Materials

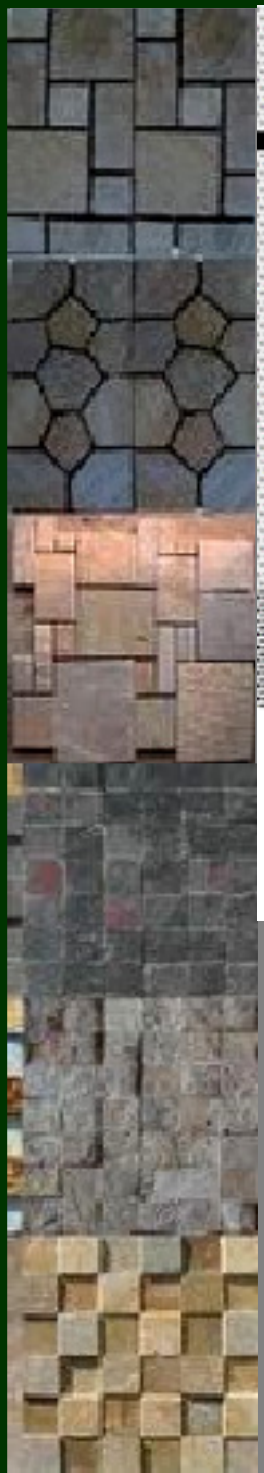
12D Permeable Pavement

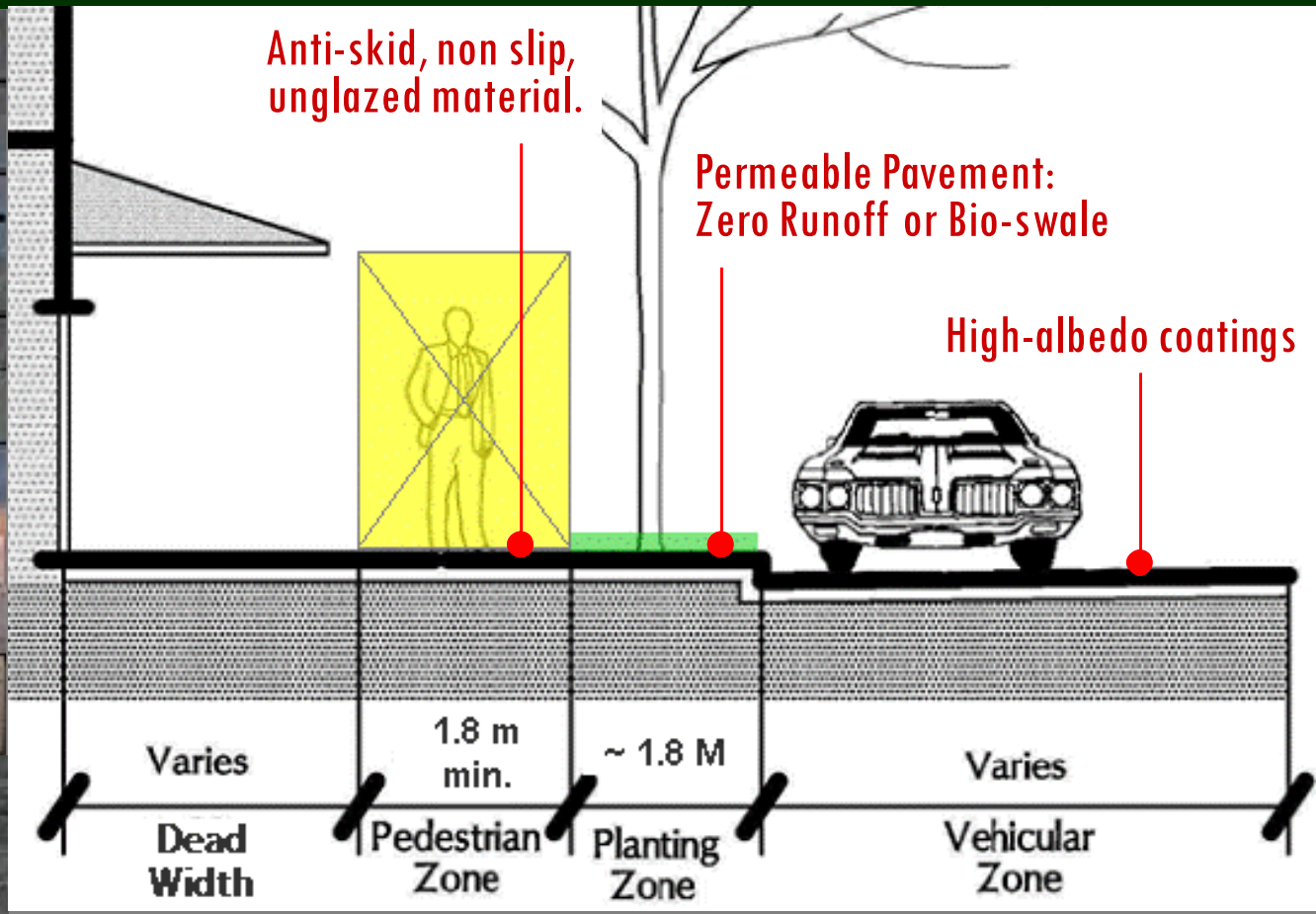
12E Paving Sub-grade

12F Edge Courses

12G Accent Materials







Appropriate Selection of Materials in design impacts the aesthetics, usability and comfort of the street for all its users – and in the long run has a huge impact towards endearing these places to the people of the city.

Materials selected should have minimal impact on the environment in terms of carbon emissions, embodied energy, life-cycle costs, quarrying, transporting and top-soil preservation. Materials selected should reduce storm w ater runoff and urban heat island effect, as much as possible.

Not Preferable

12A Material Selection Guidelines

Recommended Materials for Exterior Use:*

	Areas	Do's	Don'ts
1	Footpath	Anti skid / matt finish tiles, interlocking paving tiles, sandblasted Stone, unpolished Stone, checkered tiles	Polished Stone finishes
2	Kerb ramps	Anti skid / matt finish tiles; Flared sides with tactile paving, exposed Cement Concrete	Polished Stone finishes
3	Tactile paving	Vitrified unglazed pavers in bright colour contrast to the flooring surface (preferably canary yellow)	Stainless steel or metal pavers in dull /slippery finish
4	Signage	Bright colour contrast big font signages on non-glare surface- acrylic, metal (fully painted) with retro reflective paints	Glass, stainless steel, aluminum
5	Bus Stops flooring	Anti skid / matt finish tiles with vitrified unglazed tactile pavers in bright colour contrast to the flooring surface	Glazed vitrified tiles, Granite, polished Kota stone
6	Streetlights	White color, mercury lights- full cutoff fixtures	Yellow lights
7	Handrails	Stainless steel 304/316, OD- 40-45mm, scotch-brite or matt finish	
8	Light signals	Audio signals with time display	Normal light signals
9	Table top	Any load bearing anti-skid pavers, tiles	Cobble stone
10	Table top slopes (on road side)	Cobble stone maybe provided	Polished granite or any other Slippery Surface
11	Median refuges	Any load bearing anti-skid pavers, tiles	Cobble stone
12	Cycle tracks	Preferred Pavement Quality Cement Concrete	CC Paver Tiles and Polished Finishes

*Prepared in consultation with Samarthyam, TRIPP and SGA

All paving materials, as a rule – should be finished as anti-skid, non slip, unglazed material.

Key Guidelines:

1. Locally Available Materials should be preferred i.e. majority of the materials should be available within 250 km of site.
2. Since most road projects are redevelopment projects – Reuse/ recycling existing road construction materials is preferable and advisable.
3. Materials which have some recycled content or that can be recycled after use should be preferred. E.g.
    - Recycled Asphalt
    - Recycle Rubber
    - Flyash
    - Recycled stone or other existing construction materials.
4. Long life, durability and ease of repair of materials must be factored in during material selection and project cost calculations.
5. Use and depletion of finite raw materials should be reduced - by replacing them with rapidly renewable materials. (Rapidly renewable materials are ones that are typically harvested within a 10 year cycle, eg, bamboo products, corn products, wheat based products, strawboards etc.).
6. Materials with low cement content and low embodied energy should be given preference.

Recommended Options:

Materials which have some recycled content or that can be recycled after use should be preferred. E.g:

- Recycled Asphalt
- Recycled Rubber
- Flyash
- Recycled stone or other existing construction materials.
- Recycle components in Concrete

Not Preferable

Why is traditional Asphalt environmentally unsustainable !

Excessive use of stone Aggregate component of Asphalt – leads to excessive mining/ quarrying which implies:

- Use of water and fuel for mining (= CO_2 emissions)
- Quarries abruptly interrupt the continuity of open space, ruining habitats for flora and fauna alike
- Stone quarrying causes air pollution, most notably dust

12B-i Recycled Asphalt

Asphalt pavement is commonly composed of 5 percent asphalt (a petroleum derivative) and 95 percent Coarse (stone, gravel), and Fine (sand) aggregates - laid down in layers and compacted.

Asphalt Pavements are highly recommended if the following substitutes are incorporated:

1. Aggregate Substitutes for Asphalt Pavement:*


Nonferrous Slag


Low-carbon content Fly Ash


Scrap Rubber Tyres

- **Substitutes for Coarse Aggregate = Crushed concrete, foundry sands, hydrated coal fly ash and slag.** Air cooled blast furnace slag and steel slag in particular provide good rutting resistance and superior friction properties, making it a choice aggregate for the surface course.
- **Substitutes for Fine Aggregate = Addition of about 35 volume % Coal Fly Ash** to the aggregate component of hot-mix asphalt (HMA) enhances the resistance of the asphalt to cracks and potholes. **This new type of hot-mix asphalt should last at least five times longer than the normal hot-mix asphalt.**
- **Asphalt Binder Modifier = Ground Recycled Rubber**, if added to the HMA prior to mixing with the aggregates, allows it to chemically react with the mixture. Asphalt concrete pavements made with rubber modified asphalt cement tend to have less cracking, and wear better than regular pavements. They also significantly reduces traffic noise when used on carriageways.

www.pwri.go.jp/team/pavement/english/subject/projects.html

2. **Asphalt pavement could potentially be 100% recyclable** and be reused as a Subgrade **[See 12D]** for new streets.
3. **High-Albedo Coatings** along with color pigments may be applied to Asphalt –to reduce Urban Heat Island Effect [See 12C]

Functional and Cost Benefits:

- The hydrophobic nature of fly ash gives pavements better resistance to cracking & potholes, making them safer and more durable, with a longer Pavement life.
- Cost saving by decreasing the need for asphalt binder.
- Less expense and frequency of required maintenance treatments to keep the pavement in good functioning condition.
- Reusing materials reduces the need for mining virgin aggregate and the associated environmental impacts. (See left)

La-Bisbal, Spain

Manhattan, New York

Padova-Italy

a) Imprinted Asphalt:

Machine-heated asphalt, imprinted with a pattern template and colored with protective coating.

Application:

- Pedestrian Dominated Streets with restricted vehicular traffic [See 11D], Pedestrian only streets, Plazas

Benefits:

- Can be installed on existing asphalt that is in good condition.
- More cost–effective and easier to maintain than unit pavers.

b) Hexagonal Asphalt Pavers:

Asphalt pre–cast into hexagonally-shaped pavers.

Application:

- High wear and tear Sidewalks

Benefits:

- Hexagonal pavers are relatively easy to reset or replace, especially for utility access.
- Easy to replace and/or recycle.

c) Thermoplastic Imprinting:

Thermoplastics applied into grooves created by heating and imprinting the asphalt.

Application:

- Crosswalks/ Road Markings
- Public Art on Streets

Benefits:

- Because the thermoplastics are imprinted below the level of the road surface, the application will not begin to wear until about ¼ inch of the asphalt has been worn away, resulting in a longer lifespan than typical thermoplastic crosswalks markings.

Source: New York Street Design Manual
Photo Credits: Integrated Paving Concepts

Not Preferable

Why is Concrete the most environmentally unsustainable

a) Extremely high GHG Emissions:
The cement industry produces 5% of global man-made CO_2 emissions, of which 50% is from the chemical process of heating Calcium Carbonate, and 40% from the burning fuel.

b) High Embodied Energy:
The process of cement manufacture uses large amounts of Energy.

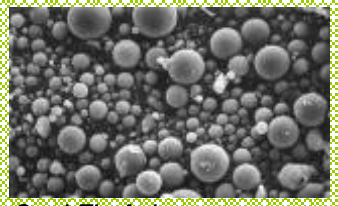
c) Mining of Virgin Aggregates:
The coarse and fine aggregate components of concrete lead to excessive mining and quarrying with its associate negative impacts like fuel and water consumption, habitat destruction and CO_2 emissions.

12B-ii Concrete with Cement & Aggregate Substitutes

Cement – an integral component of Concrete – is the single biggest material source of carbon emissions in the world. The use of Concrete for roads and pavements is NOT recommended unless the following components of traditional concrete are substituted:

1. Cement Substitutes in Concrete = Class F Fly-Ash*

Owing to its pozzolanic properties, Class F Fly ash can be used to replace 30-70% by mass of Portland cement. This has been successfully implemented in various projects around India.


Coal Fly Ash

Benefits:

- The setting time of Flyash concrete is slower BUT the final concrete's strength, chemical resistance and durability is substantially higher.
- Due to the fineness and spherical shape of fly ash particles, the fluidity and workability of fresh concrete is much higher, thus reducing water demand during mixing.

2. Aggregate Substitutes = Recycled glass cullet; Crushed recycled concrete itself*


Recycled crushed concrete

- **Concrete made with recycled concrete aggregate** has at least two-thirds the compressive strength and modulus of elasticity as natural aggregate concrete


Recycled Glass Cullet

- **Crushed and screened waste glass** may be used as a Fine Aggregate i.e. Sand substitute in concrete, e.g. "non-recyclable" clear window glass and fluorescent bulbs. Possible applications for such waste-glass concrete are bike paths, footpaths, gutters and similar non-structural work.

Application:

Bike Paths, Footpaths, Gutters and any non-structural concrete works.

*Source: Toolbase Services
http://www.toolbase.org/TechInventory/

12B-iii Clay Substituted: Fly-Ash Bricks

Not Preferable

Bricks are one of the most long lasting an beautiful materials that can be used for pedestrian paved areas. However, they are recommended only of the following substitutes to Clay are incorporated:

Why are Clay Bricks environmentally unsustainable !

a) **Top Soil Depletion:**
The Clay used for Brick manufacture generally comprises of the fertile top-soil which is ideal for agriculture. Depletion of this fertile top soil is highly undesirable.

b) **High Embodied Energy and GHG Emissions:**
The process of burning bricks in a kiln during manufacture consumes large amounts of Energy and causes huge Green House Gas Emissions.

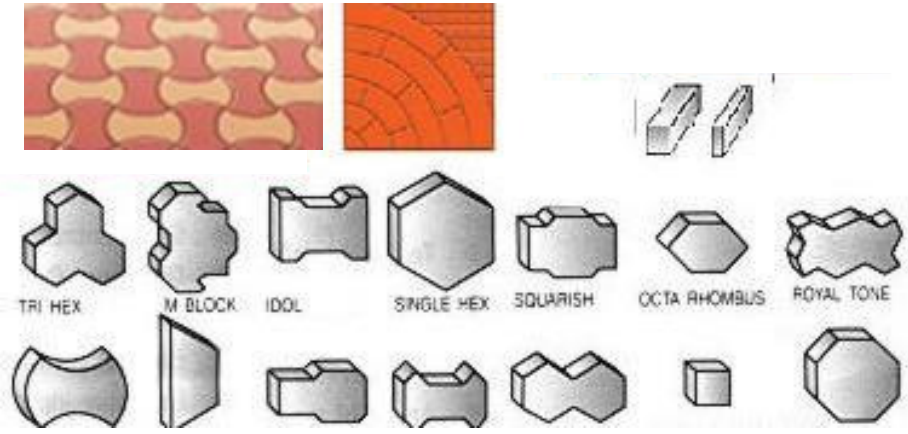
Fly-Ash Bricks (FAB) are the most desirable alternative to traditional Clay-fired Bricks:*

a) **Composition:**
FABs comprise of Class C Fly ash –a waste product of the coal-power industry, sand and other additives. Pulverized Class C Fly Ash is a self-cementing material which gradually hardens on contact with water.

If not used for bricks, fly-ask is a waste product that pollutes the environment further by landing up in landfills.

b) **Manufacture:**
Fly Ask bricks require no burning and are manufactured by a steam bath and compression process and then toughened with an air entrainment agent.

c) **Benefit:**
Beautiful material achieved at 20% less cost and a fraction of the Energy Consumption and Carbon Emissions of a traditional clay brick.



Flyash Bricks and Pavers are widely available with various Manufacturers in India.
Pictures Source: Alibaba.Com, Global Trade Portal

Application: Plazas, Seating and Accent Areas.

*Source: The Building Brick of Sustainability: Construction Specifications Institute Magazine
http://calstarproducts.com/wp-content/themes/default/pdf/BldgBrick_Sustainability.pdf

12B-iv Recycled Rubber Pavement

Recycled Rubber Sidewalks in Vancouver, CN

Easy to mould around trees, ramps, etc.

Extremely easy to apply and repair.

Benefits	Rubbersidewalks
Life Cycle Near Tree Roots	15+ years
Life Cycle In Freeze-thaw	15+ years
Installed Material Cost*	$19.80/sf
Crew Needed	2 man crew
Completion time	500 sf/day
Recycled Content	100%
ADA Compliance	Low vibration
Size	2'x2.5' x 1.875"
Weight	10.8 lbs/ sq ft
Appearance Changes	Darkens over time
Mass Changes	Possible settling
Trip Hazard	Low to zero
Maintainability	100 percent ($1.50/sf)
Walking Comfort	Highest
Porosity	Highest
Coefficient of Friction (non-skid)	.90 Dry/.65 wet
LEED Qualified	Highest
Environmental Impact	100% recycled rubber, reduced heat island, low water run-off, low energy need

Rubber Sidewalks – are an interlocking modular open-grid pedestrian paving systems – which are potentially the most sustainable alternative to concrete paving.

- **Composite Rubber Sidewalks are being developed by the Shriram Institute for Industrial Research. Samples and Test sites are yet to be seen.**

Advantages & Cost Benefits:

- Rubber sidewalks allow periodic tree root inspection, access to utilities, without costly concrete repair and replacement. Modular system allows pavers to be periodically opened for inspection and immediately 'reinstalled'
- Rubber sidewalks are unbreakable. They can also easily be cut to fit corners and different shapes on pavements.
- Unlike Rubber sidewalks, concrete cannot be "maintained" and must be demolished, off-hauled, and replaced when damaged.

Environmental Benefits:

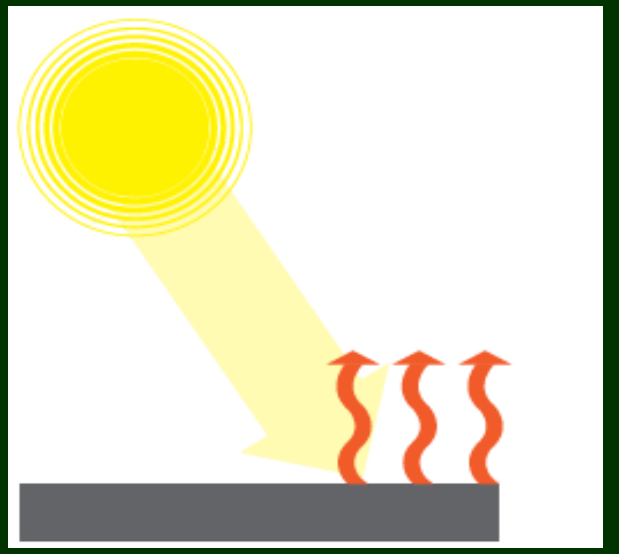
- Directs water into soil (Permeable) thus reducing water run-off into storm drain.
- Resilient though firm, more comfortable and healthy to walk on.
- Absorbs sound, reduces decibel level of foot and wheeled traffic
- Safe, non-toxic and flame resistant
- Can be used in tree wells as well as sidewalks
- Excellent for use in temporary sidewalk situations, e.g. events or construction sites.
- One-square-foot of Rubbersidewalks recycles waste rubber from one passenger tyre
- Rubbersidewalks can be recollected and recycled at the end of their life cycle and the material used again.

Application: All sidewalks.

Source: Rubber Sidewalks, Inc.
http://www.rubbersidewalks.com/pdf/Fact_Sheet.pdf

Not Preferable

Dark colors of some materials such as asphalt, tremendously increases the urban heat.



Darker paving absorbs more sun-rays and radiates it back as infra-red, increasing ambient air temperature.

12C/01F High Albedo Materials

High Albedo/ 'Reflectivity' Materials reflect more of the sun's rays and absorb less heat than traditional black asphalt pavement or darker paving materials, thus mitigating the urban heat island effect.

- Most cool pavements use materials such as lighter colored aggregate, sand, and cement products.
- **High Albedo Materials can reduce pavement surface temperatures by 11°C-22°C**, and this may increase pavement life.

Key Design Guidelines/ Application: 01F

- **Choose light-colored pavers (Light gray, beige and tan colors), aggregates or top coats, preferably with a reflectivity of 0.29 or higher.**
- Parking lots, pavements, roads, driveways and other surfaces can have **coatings or integral colorants** added to increase reflectivity.
- If paving with asphalt, applying a **white aggregate as a chip seal layer**, or a light-colored surface coating such as a zinc-oxide slurry mix.

Table 6.2 Comparative Unit Costs of Selected Pavement Treatments*

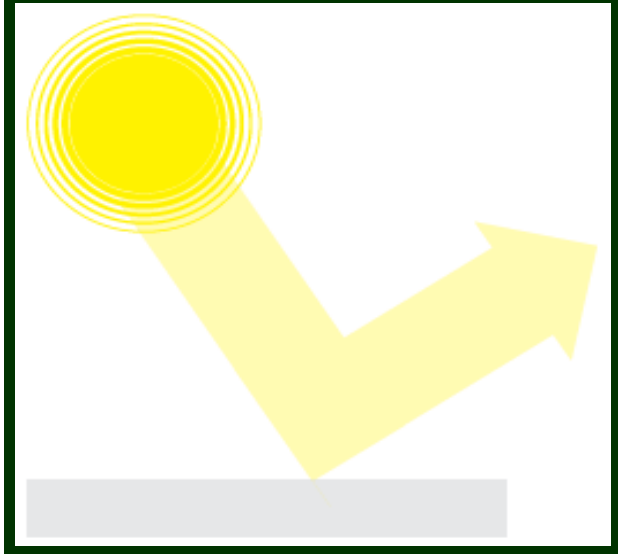
Treatment	Unit	Unit Cost†, $/SY/in or $/SY	Estimated Service Life, Years
Hot-mix asphalt	SY/in	$1.00-$1.50	7-20
Plain-jointed portland cement concrete	SY/in	$3.00-$5.00	15-35
Reinforced concrete	SY/in	$7.00-$13.00	15-35
Whitetopping	SY/in	$3.00-$5.00	10-15
Ultra-thin whitetopping (refer to text)	SY/in	$40.00-$60.00	Relatively new technique
Slurry seals	SY	$0.90	2-8
Microsurfacing	SY	$1.25	5-10
Chip seals	SY	$0.85	2-8
Thin hot-mix overlay	SY	$1.75	2-12

Heat Island Reduction Initiative, U.S. Environmental Protection Agency

Best Practices

Light-colored paving; Carter Road Promenade, Mumbai

Highway showing left side paved with high-albedo asphalt and the right side paved with conventional asphalt.



By reflecting more sunlight, lighter–colored paving reduces the urban heat island effect

Not Preferable

After 2 hours of rain....

After 4 hours of rain...

The increase of impervious surfaces in Delhi has led to serious flood issues.

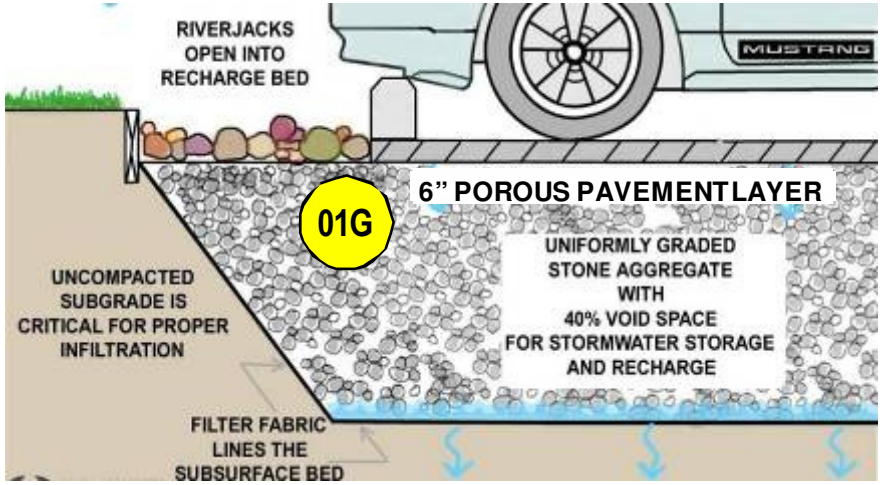
12D/01G Permeable Pavement

Permeable pavement is a paving system which allows the rainfall to percolate into an underlying soil or aggregate storage reservoir, where stormwater is stored and infiltrated to underlying subgrade, or removed by an overflow drainage system.

Permeable pavements provide ground water recharge and reduce pollutants in stormwater runoff into rivers and Nallahs.

Application:

- Permeable paving is most suitable for large paved areas without heavy foot traffic or any fast vehicle movement. Therefore, all areas within the **Multi-Functional Zone** [Section 04], **parking lots, driveway kerb-cuts, large plazas, hawker zones, pedestrian only streets, etc. are most suitable for permeable pavements.**
- **The sub-grade of porous paving surfaces must be porous to a minimum depth of 150 MM well** – in order to achieve the desired level of permeability.



http://www.mapc.org/regional_planning/LID/permeable_paving.html

Best Practices

Parking Lot in Sydney, Australia

Hawker Zone in Shanghai, China

Permeable Rubber Sidewalk in Vancouver

A

Permeable Asphalt

Fundamentally the same as regular asphalt, but it does not contain the fine particles that asphalt does, hence, creating porosity.

•**Need to be cleaned 2 to 4 times a year to avoid build-up of debris**. But some research has found that even with 99% clogging the infiltration rate can be up to 10 inches/hr.

•It **does not require special training** and can easily be supplied by conventional asphalt batch plants

B

Permeable Concrete

This is a variation of traditional concrete, but without the fine particles in the mix.

•Installation is quite different from the traditional method, and **requires experienced installers** both in the mixing and laying of the product.

•Proper maintenance includes periodic vacuuming of the surface to **prevent clogging with sediment or organic material.** With proper maintenance it can last a minimum of 20 years.

C

Interlocking Concrete Pavers

Themselves are not always permeable, but they are typically installed with gaps between them to allow infiltration into the subsurface. The gaps, typically 10% of the surface area, are filled with a permeable material, usually small clean stone.

•**They have a long useable life, are relatively easy to install** and provide good infiltration.

•However, they are **sensitive to deformation** in the base and do require a thick base to prevent "heaving."

D

Open-Celled Paving Grid with Vegetation

Open-celled paving grids consist of a rigid grid composed of concrete or a durable plastic that is filled with a mix of sand, gravel, and topsoil for planting vegetation.

•The plastic grid pavers are also **flexible, allowing them to be used on uneven sites**.

•They do not require another drainage facility and are **competitively priced to asphalt and concrete paving**, when their required drainage costs are factored in.

E

Open-Celled Paving Grid with Gravel

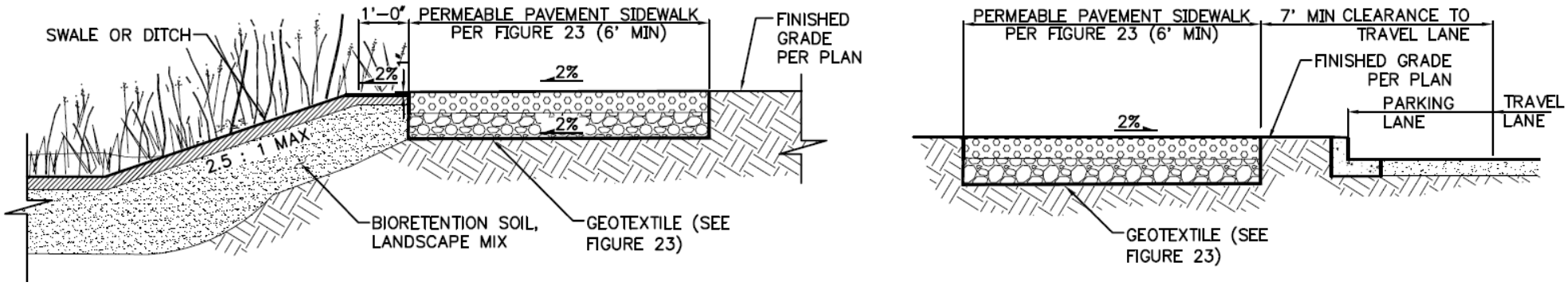
The same open-celled grid structure is employed but the voids in the rings are filled with a mix of gravel.

•With the gravel in place this grid system does **provide additional structural support.** And since most grid-cell material is plastic, hence flexible, it can adapt well to shrink/swell and freeze/thaw conditions.

•Most commercially available geocell material is made from recycled material, an added environmental plus.

Source: Seattle Right of Way Improvement Manual and UC Davis Research

12D/01G Permeable Pavement



Application and Design Considerations:

In general, sites where pervious pavement will be installed needs to meet the following criteria:

- Soils need to have a permeability of at least 0.5 inches per hour. An acceptable alternative design for soils with low porosity would be the installation of a discharge pipe from a storage area or "Percolation Pit".
- Areas that have high potential for contamination such as transfer stations, gas stations, or highly industrial areas may not be suitable for permeable pavements due to the increased risk of groundwater contamination.
- The bottom of the stone reservoir should be flat, so that runoff can infiltrate through the entire surface.
- The seasonal high water table should be at least 1M below grade.
- It should be installed at least 30 M away from drinking water wells.
- Pervious pavements should not be used in areas with a slope > 15%, as erosion of the fill material may occur.

Maintenance for All Permeable Pavements is critical to their performance:

Permeable pavements and pavers require some additional maintenance to keep them functioning properly:

- Inspect for surface material that may clog the pavement: Inspect the project upon completion to remove any fine material that has accumulated on the surface. Conduct periodic visual inspections to determine if surfaces are clogged with vegetation or fine soils. Clogged surfaces should be corrected immediately.
- Periodic vacuum sweeping or pressure washing: Permeable concrete and permeable asphalt surfaces should be swept with a high-efficiency or vacuum sweeper at least once every month. High pressure hosing could substitute for sweeping or supplement sweeping if material appears clogged. For gravel pave or unit pavers, replace gravel if clogging occurs.
- Replenish aggregate: Replenish paver aggregate material as needed.

Source: US EPA National Pollutant Discharge Elimination Systems

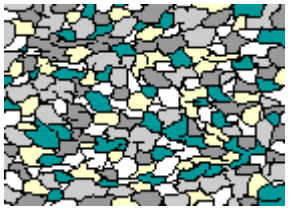
12E Sub-Grades and Sub-Bases

[12 B] **Paving** as per design - over mortar or appropriate binding material

Mortar 4:1 = Sand: Cement

Bedding layer carries the final surface layer. This is usually a coarse grit sand, with a low clay content and with good drainage properties.

Sub-Base layer is often the main load-bearing layer of a pavement.



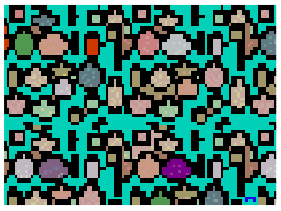
Unbound Materials rely on natural interlock.

They are Permeable;

May comprise:

- Generally a mixture of coarse (gravel) and fine (sand) aggregate.
- Could also comprise of crushed stone, crushed slag, crushed concrete or non-plastic well-burnt shale.

Application: Universal



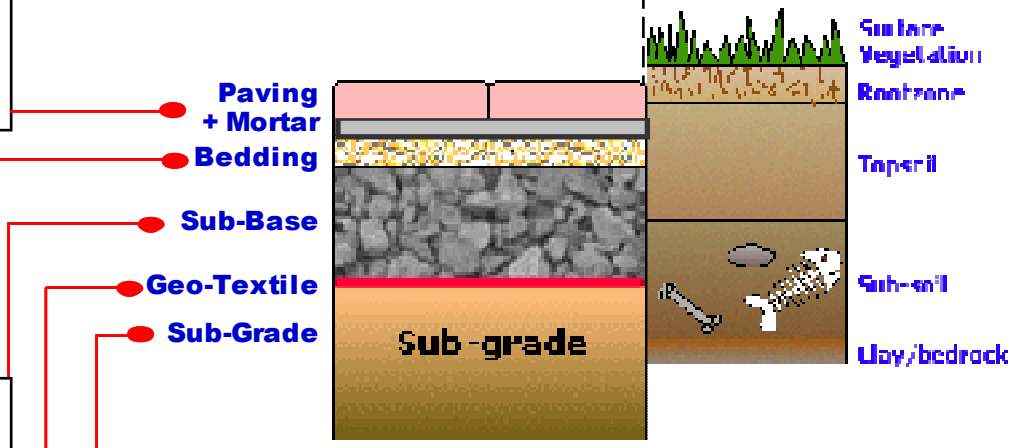
Bound materials use a binder like cement or bitumen (tar).

They are Impermeable.

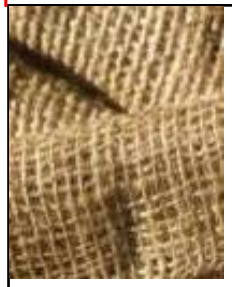
May comprise:

- 100-150 MM thick cement concrete slab
- Recycle granular materials like blast-furnace slag, mixed with cement and water and compacted.

Application: Only pavements where heavy loads or bad grounds are expected.



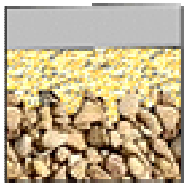
Sub-Grade . is the lowest point of the pavement structure - the underground level at which excavation ceases and construction starts. Sub-grade mostly comprises of compacted earth, except for Permeable Pavements where it must be kept uncompacted.



Geo-textile Fabrics – like GeoJute, etc. These are often non-woven, permeable sheets applied between pavement layers to prevent the various layers of the pavement mixing or disappearing into lower layers. They thus prevent premature cracking of the surface pavement layers, especially Asphalt.

Functions: Separation between base layers where required; Filtration (liquids and gases); Reinforcement of pavement layers.

Applications:

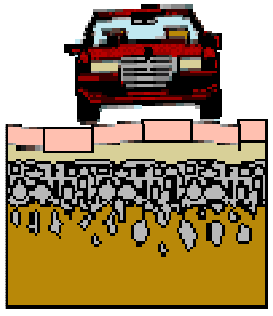


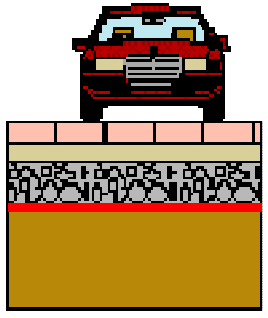
Bedding can settle into voids in sub-base

Between Bedding & Sub-Grade

Geo-fabric stops bedding settling into sub-base

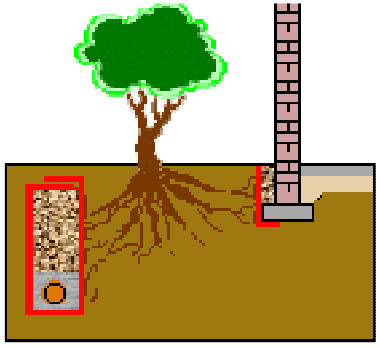
Between Bedding & Sub-Grade





In case of clayey soil, geo-textiles help keep the overlying sub-base material from sinking into a clayey or softish sub-grade.

Between Sub-base & Sub-Grade



Root Barrier Geo-textiles protect drainage and foundations

Around utilities & foundations

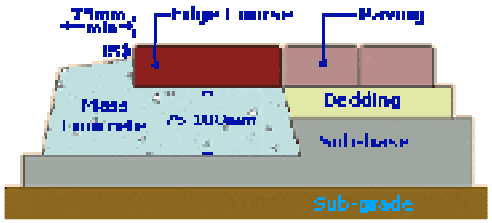
Source: PavingExperts.Com; Jmdcindia.com

Edge Courses – Functions and Applications:

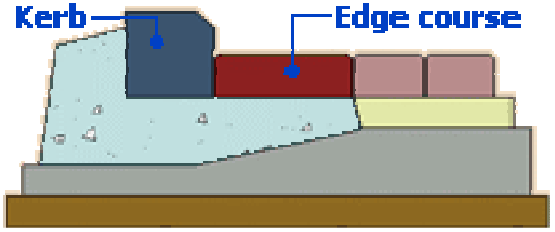
Edge courses provide a number of functions in a properly constructed block pavement. These functions can be divided into three categories:

Structural:

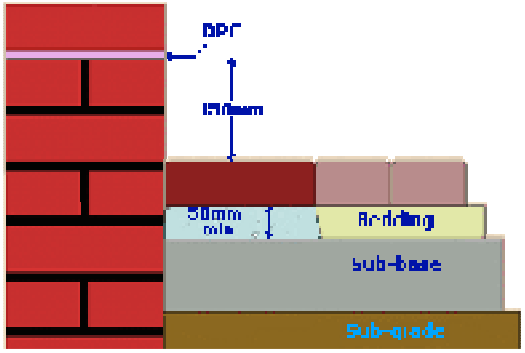
They form the restraining edges for a pavement.



Edge Course functionally important at a Free Edges (e.g. parks, soft edges, etc)



Where a kerb is present, the edge course may be purely functional/aesthetic.



Edge Courses at building edges can help direct water away from building foundations.

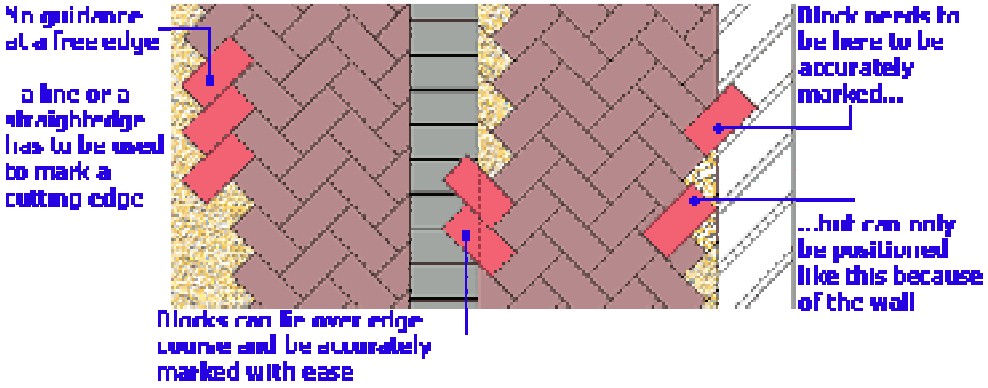
Functional:

They eliminate the need for cut blocks at the edge of a pavement.

They can be used as level guides for preparation of the screeded bed.

They facilitate cutting-in procedures.

They can act as drainage channels, directing surface water to a suitable disposal point.



Brick Drainage Channel in Walkway

Fluted Drainage Channel in Walkway

Concrete Drainage Channel in Asphalt Pavement

Aesthetic:

They form a frame to the pavement that gives it definition and shape.

Source: PavingExperts.Com

12G Accent Materials

Public Art engraved Stone Tiles with brick tile paving.

Paving in Rough Kotah stone. Seats in stone masonry. Kiosk columns clad in ceramic mosaic. (Vikas Sadan, Delhi)

Red tinted PCC Tiles and concrete bollards with glaze Ceramic tile highlights. (BRT Delhi)

Different colors and textures of Brick and Red Sandstone use to create this warm and well scaled Plaza.

Permeable grass pavers use in sloped seating area with walkway in rough finished stone pavers. (Shanghai)

Ceramic Tiles use on vertical surfaces an risers of steps to add color (Bikaji Cama Place, Delhi)

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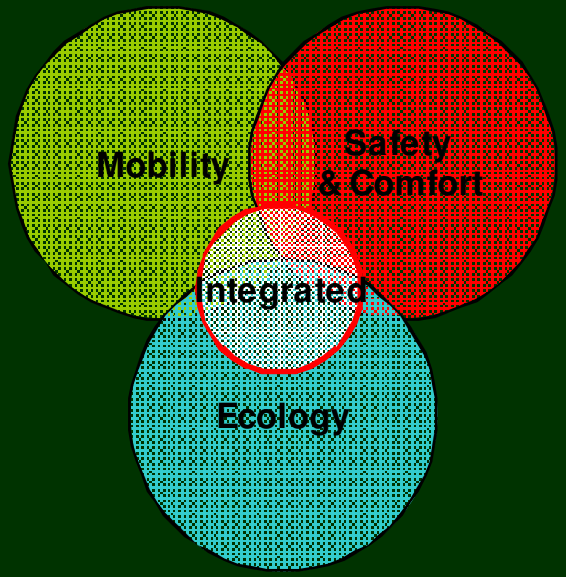
13 Public Art, Street Furniture, Educative Signage

Paving Patterns

Public Awareness Campaigns

Manhole cover art, Chandigarh



Public Art in Delhi must be integrated with regular street furniture, Signage or Education and Awareness Messages, etc. in order to play a dual role – "utility" as well as "aesthetics". It can be a powerful tool for education and outreach. Carefully designed art could have a significant impact on the behavioral patterns of people.

Public Art also helps build civic pride and a sense of ownership amongst citizens, especially if local communities can be involved in their installation, renewal and maintenance.

Street Furniture is an important component of streets as it helps create resting or "pause" spaces along the daily paths of people and makes streets more enjoyable. All Street Furniture should be located within the Multi Functional Zone and kept CLEAR of the designated Walking and NMT zones of the street.

ELEMENTS OF THE URBAN INFRASTRUCTURE POSSIBLY USABLE AS PUBLIC ART (Suggestive Only):

- Pavements
- Manhole Covers
- Dustbins
- Bus Stops
- Boundary Walls
- Fences and Handrails
- Public Toilets
- Pavements
- Tree Trunks
- Street Furniture

Not Preferable

When there is no feeling of belonging, pavements are not maintained and littering is common

A Common Site in Delhi due to the abundance of unwatched boundary walls.

13A Boundary Wall Art!

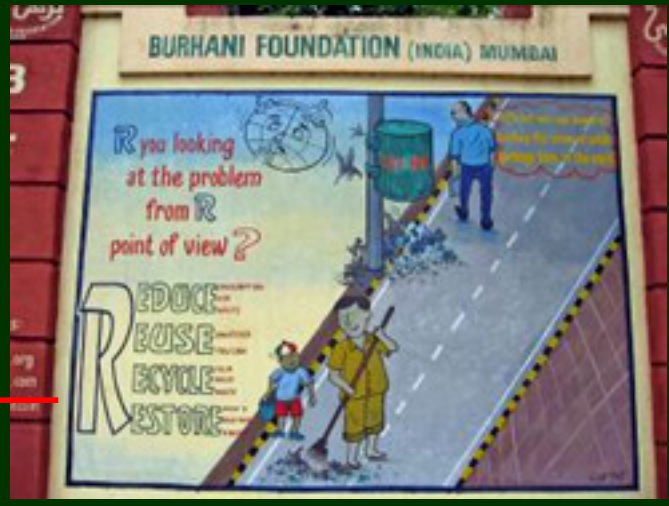
The long-term solution to walls and footpaths being used for public urination and spitting - **is the removal of boundary walls and creating "eyes on the street" – which would also make the city safe for women.** See page 21.

In the short-term – **the abundant boundary walls around the city could be used for educative public art.**

A Boundary Wall in Kalbadevi, Mumbai used for 'Environmental Education' Art – created by children through NGO cooperation.

Best Practices

Educative Public Art on boundary walls is used as a "**Signature Statement" throughout the Streets of Philadelphia, US**



13B Art on Dustbins, Bollards

Innovative, clean, well maintained and well loved Dustbins are the key to a "Clean" City.

- An Artistic way (graphics, cartoons) could convey – why and what kind of waste should go into which bin – even to illiterate users.

- In Philadelphia, Art on Dustbins strongly convey the Environmental Philosophy of the City.

- Maps on dustbins showing location of nearest landmarks and public toilets.

"How to use" Delhi's new 'source separated' dustbins is a mystery to most people in the city.

Bollards play a huge role in segregating areas for "pedestrian use only" and help increase safety and usability of public spaces and footpaths.

- Bollards could be designed as expressions of **public art** (through city level design competitions or design festivals).
- This would help generate civic pride and a sense of ownership amongst Delhi citizens.

▪Full Cutoff Bollard Lights enhance visibility without Glare.

Not Preferable

13C Social Art at Bus and BRT Stops, Metro Stations.

Art for Conveying..... Important SOCIAL MESSAGES:

Bus stops can be used as canvases of public art conveying messages about

anti-eve teasing, anti-molestation of women, anti sexual abuse etc....

Example of Social abuse Signage at a Bus Stop in New York.

Safety Data of Delhi shows that most women find buses and bus-stops the MOST UNSAFE places in Delhi.

"The most unsafe time out - 40% felt unsafe between 8 and 10 am and 5 and 7 pm. 31% felt unsafe in mid-afternoon.

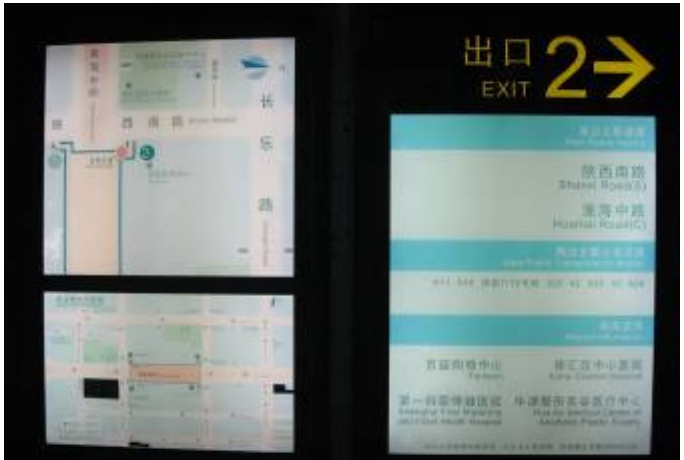
***Most unsafe places** - 45% identified buses as the most unsafe; 25% the roadside; 6.7% found bus stops..."*

– A Delhi Police survey on women's safety, 05 March 2006.

Source: http://southasia.oneworld.net/article/view/127142/1/

13C Maps at Bus and BRT Stops, Metro Stations.

- Adequate Wayfinding Signage and well-designed, artistic and bi-lingual "Local Area Maps" should be displayed at all Metro Station Exits and at Bus Stops – showing local roads and important civic destinations.
- Bus Stops and Metro Stations should also display an Overall System Route Map.
- Information about bus routes and timing must also be displayed in static signage (even if intelligent signage exists).



Local Area Map & Info: at a Metro Station Exit in Shanghai.

Map © SFTMA.COM


Local area map at a bus stop, Shanghai

Advertising and Signage at a bus stop, Delhi

Not Preferable

Lack of Adequate Seating Facilities in the City, especially near Transit Stations

13D Street Furniture: Seating Areas, Pause Spaces...

Seating is an essential piece of Street Furniture which provides pedestrians and especially public transport users an opportunity to rest or pause, in the mist of their daily schedules...

- Seating provided must be easy to clean, located in areas that are well watched, busy, and well shaded by trees or artificial canopies - to protect people from the harsh Delhi heat.
- Ideally low maintenance seating should be located under deciduous trees and designed for easy cleaning and maintenance.

Functional Public Art: SHADED SEATING....
Chair extensions hold up the roof over your head, while providing a seating place at the same time.
(Street furniture: Hudson Riverfront, New York)

Well shaded, easy-to-maintain Seating, Beijing

13E Art & Awareness: Trees, Planting, Public Involvement.

The Delhi Tree Plantation Drive could be more streamlined towards planting new trees along **streets and in specific urban areas where aforestation has taken place** or areas where green areas are scarce.

School children should be involved in not **only planting but also monitoring the growth** of saplings so that they develop a sense of ownership to their work and in turn the city.

An online or tele-volunteering program could be launched, once areas for planting are identified and designated.

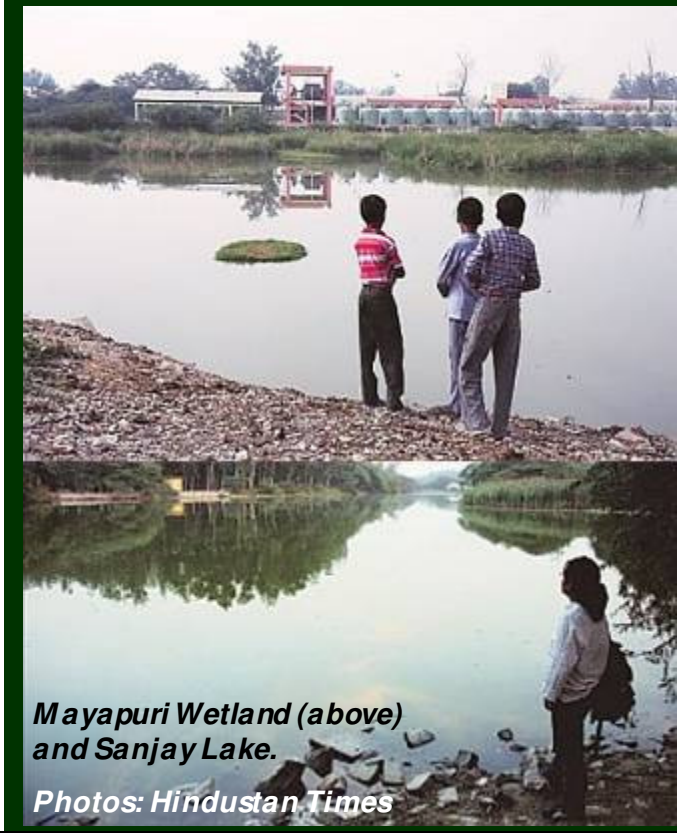
Trees as simple Public Art...adding color!

Green Streets, Portland

As per Guideline 04C, when Natural Storm Water Management Systems are implemented in the city ***- Generating public awareness about these "living streets" will be very important for the maintenance and success of these projects.***

Wetland Centre, Hong Kong

Wetland Centres could be set up near the neglected and dilapidated natural lakes and wetlands of Delhi (e.g. Sanjay Lake, Mayapuri Wetland, etc.) to make people aware of natural storm water systems in the city and the importance of maintaining the Nallahs, street-swales, etc.



Mayapuri Wetland (above) and Sanjay Lake.

Photos: Hindustan Times

13 Public Art, Street Furniture, Educative Signage

Public Art: Cycle Parking at Powell Books, Portland

Pedestrian & cycle subways under Railway Tracks, etc should be well lit and incorporate local public art - to give a sense of ownership with the community.

Recycled bicycle parts - for seating

Street banners would give a sense of place and identity to unique neighborhoods and destinations of the city.
They are easy to install – banner supports can be clamped on the existing streetlamps or other street poles.

14 BRT Systems, Bus and HOV Lanes

14.1 'Closed' BRT System

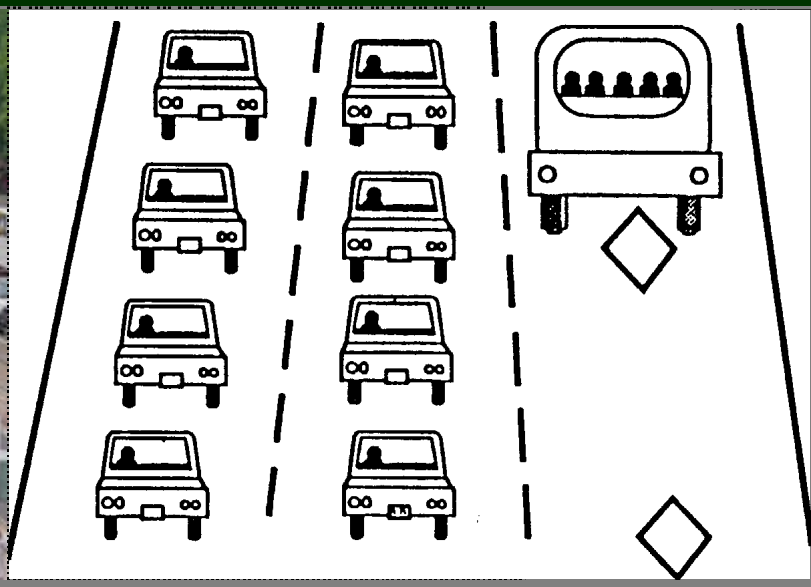
14.2 'Open' BRT System

14A Common features of both BRT Systems

14.3 HOV/carpool/bus lanes

14.4 Bus-Only Corridors

14.5 Guided Busways



Bus corridors are an initiative to give dedicated road space and traffic signal priority to buses in order to reduce journey times and improve service consistency. The aim is to encourage people to shift to public transportation thus helping 'escape' traffic congestion.

The NUTP 2006 has recommendations for realizing these policy objectives:

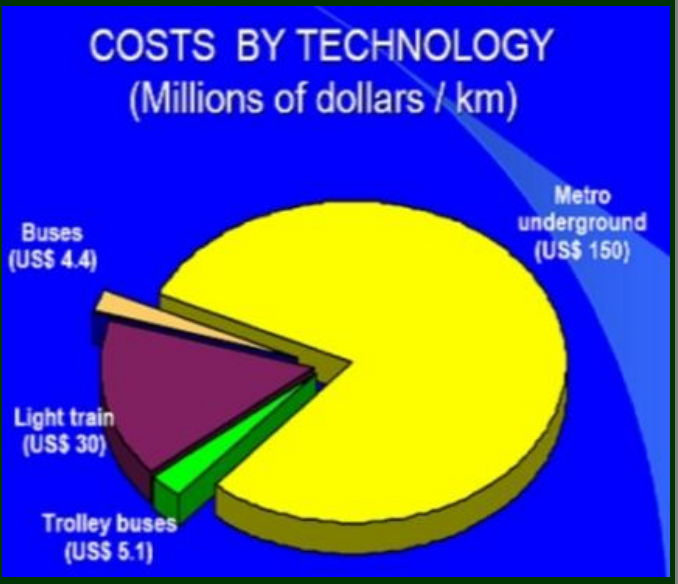
- By reserving lanes and corridors exclusively for public transport and non-motorized modes of travel.
- Similarly lanes could be reserved for vehicles that carry more than four persons (known as High Occupancy Vehicle Lanes).
- India as a developing nation must promote wheel-based Public Transportation because of affordability issues with Delhi leading the way.
- Need for a guidelines to ensure flexible, efficient implementation of all typologies.

Masterplan of Delhi 2021 specifies:

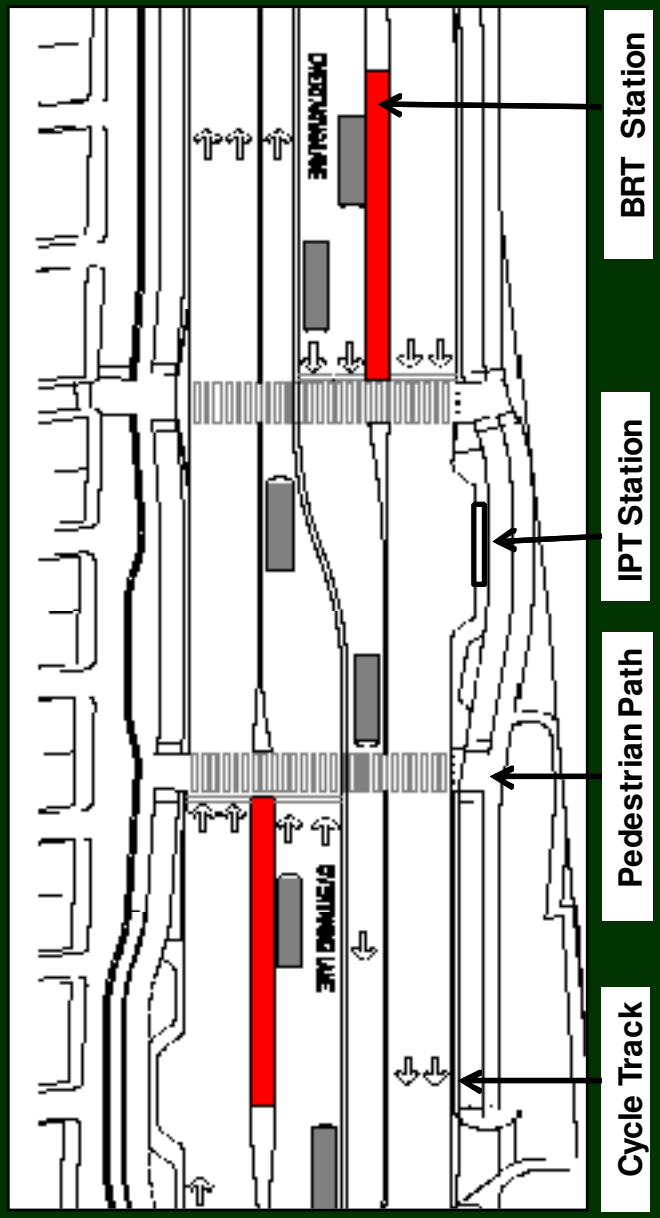
On all roads with ROW greater than 30 m exclusive bus lanes will be planned to implement the Bus Rapid Transit System (BRTS) in a phased manner to cover the whole city.

Why Bus Corridors?

- Increases the efficiency and capacity of an existing road manifold, **by moving more people, not vehicles.**
- Substantially cheaper than Metro and other Rail-based systems
- Can run on narrow corridors and integrate with street life at-grade, as no grade separation is required, therefore does not create physical barriers for neighborhoods, cyclists, pedestrians or cars.
- Can and must integrate seamlessly with pedestrian and non-motorized transport networks.
- Flexible – can provide last-mile connectivity and alternate between a high-speed and local bus systems, as per System Design.



14 Types of Bus Corridors



Mid block BRTS Station integration with IPT

TYPES OF BUS CORRIDORS:

1. **'Closed' Bus Rapid Transit System:** is one that uses fully segregated and *operations controlled* corridors to provide a high capacity, high-speed, reliable and efficient Rapid Transit System, at much lower cost than rail based systems, and without the need for grade separation.
2. **'Open' Bus Rapid Transit System:** is a flexible system which is a combination of 'fully segregated' as well as 'mixed-traffic' movement corridors for buses. It uses fully segregated, dedicated lanes to 'take out' buses from congestion and provide speed, efficiency and reliability to the overall Bus-System of the city.
3. **HOV/ Carpool & Bus lanes:** "High Occupancy Vehicle" lanes or 'bus-lanes' or car-pool lanes are lane prioritized for movement of vehicles carrying 4-people or more, especially during peak hours.
4. **Bus-only Corridors:** These are transit corridors on which only buses are allowed to ply, either during peak hours or for the entire day.

MAXIMUM capacity of a Mixed Lane = (2.2x1200) = 2640 Passengers/ Lane/ hour

MINIMUM capacity of a Dedicated Bus Lane = 9000 - 20,000 Passengers/ Lane/ hour

14.1 'Closed' Bus Rapid Transit System (BRTS)

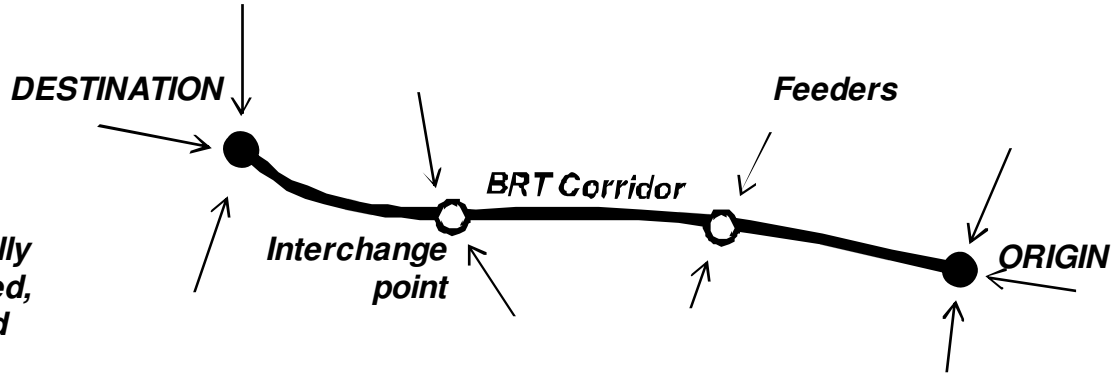
A 'Closed' BRTS System is broadly defined as a Mass RAPID Transport System that is effectively "Rail on rubber wheels".

A 'Closed' BRTS system is one that uses fully segregated and *operations controlled* corridors to provide a high capacity, high-speed, reliable and efficient Rapid Transit System, at much lower cost than rail based systems, and without the need for grade separation.

A Closed BRTS System must have the following special features:

1) **Origin-Destination (OD) based route selection.**
2) **Full Operations Control and full physical segregation of complete route.**
3) **Signal prioritization at all junctions and centralized control to ensure time-bound service.**
4) **Well designed Interchange points with Metro and integration of feeder services including local buses and para-transport modes.**

A Closed BRTS System can be combined with an Open BRT System within the same busway – to be then called a 'Hybrid System'.



BRTS Corridor is fully operations controlled, fully segregated and based on Origin-Destination (OD) criteria.

Ahmedabad

BRT S terminates at Destination points.

14.2 'Open' Bus Rapid Transit System (BRTS)

Bus on Segregated BRT Corridor above

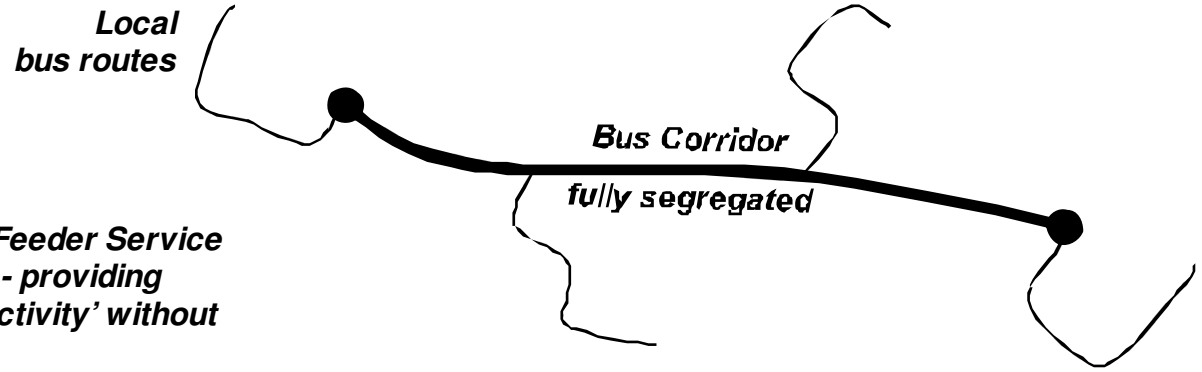
Same Bus as a feeder within neighbourhoods at end of journey

An 'Open' BRTSystem is a flexible system which is a combination of 'fully segregated' as well as 'mixed-traffic' movement corridors for buses. The System allows local bus-routes of the city to move in and out of the corridor as per requirements. Along all arterial roads and other required roads, the Open BRT System uses fully segregated, dedicated lanes to 'take out' buses from congestion and provide speed, efficiency and reliability to the overall Bus-System of the city.
(See page 150)

Note: *MPD-2021 mandates: "On all roads with ROW greater than 30 m, exclusive bus lanes will be planned to implement the Bus Rapid Transit System (BRTS) in a phased manner to cover the whole city."*

In the Delhi context, an Open BRT System would have the following features:

1) **FULL PHYSICAL SEGREGATION of bus-lanes along major corridors to facilitate smooth, interference free and congestion free movement of buses along major stretches.** (See page 150)
2) **Signal prioritization and separate signal-cycles may or may not be required for Bus corridors – this to be decided as per need and design of specific junctions along the corridor.**
3) **Interchange points to be provided with the BRTS and Metro Systems at required locations.**
4) **The Biggest advantage of the "Open BRT System" is that – once the bus leaves the fully-segregated section, the same bus can become a "feeder service" into neighbourhoods at the end of the journey – thus providing "last mile connectivity" without change of Mode.**
5) **Bus Corridors have all the features of a BRT Systems with the exception of full operations control requirements and need for signal prioritization at all junctions. The y are also not necessarily OD-based Systems and are more intended to relieve buses out of congestion.**



Same Bus as a Feeder Service in mixed traffic - providing 'last mile connectivity' without Mode change.

14A Common Components of BRT Systems:

1. Complete Physical Segregation of Busways along major corridors.
2. Prioritization through Design and Management.
3. Integration with several modes of transport including *buses, feeder vans, Auto/Taxi, bicycles, cars/two wheelers, pedestrian crossings, cycle rickshaws, and future MRTS,* to ensure quick and easy modal interchange, efficiency and integrated ticketing system.
4. Location of doors – Mostly left side doors. However both side doors may be provided as per specific site conditions requiring the use of island stations.
5. Fleet Selection – Buses must be low-floor as they ensure accessibility to all sections of users including old people, children and people on wheelchairs, both within and outside the corridor.
6. Location of the interchange points close to road junctions.
7. Coordinated Construction, Regulation of Bus Operations, Management and Maintenance of the corridors and rolling stock operations as per requirements.
8. Utilization of the land resources, advertisement rights, congestion charges etc. for financial viability of the Busway System/BRT.
9. Assurance in removal of encroachment on the RoW and potential change of land-use for the properties affected by the development.
10. Public Outreach campaign to ensure Imageability.

The first Bus Rapid Transit system implemented in the world at Curitiba, Brazil.

14A Common Components of BRT Systems:

Bogota BRT with segregated median lanes along with express lanes

Dedicated Bus ramp

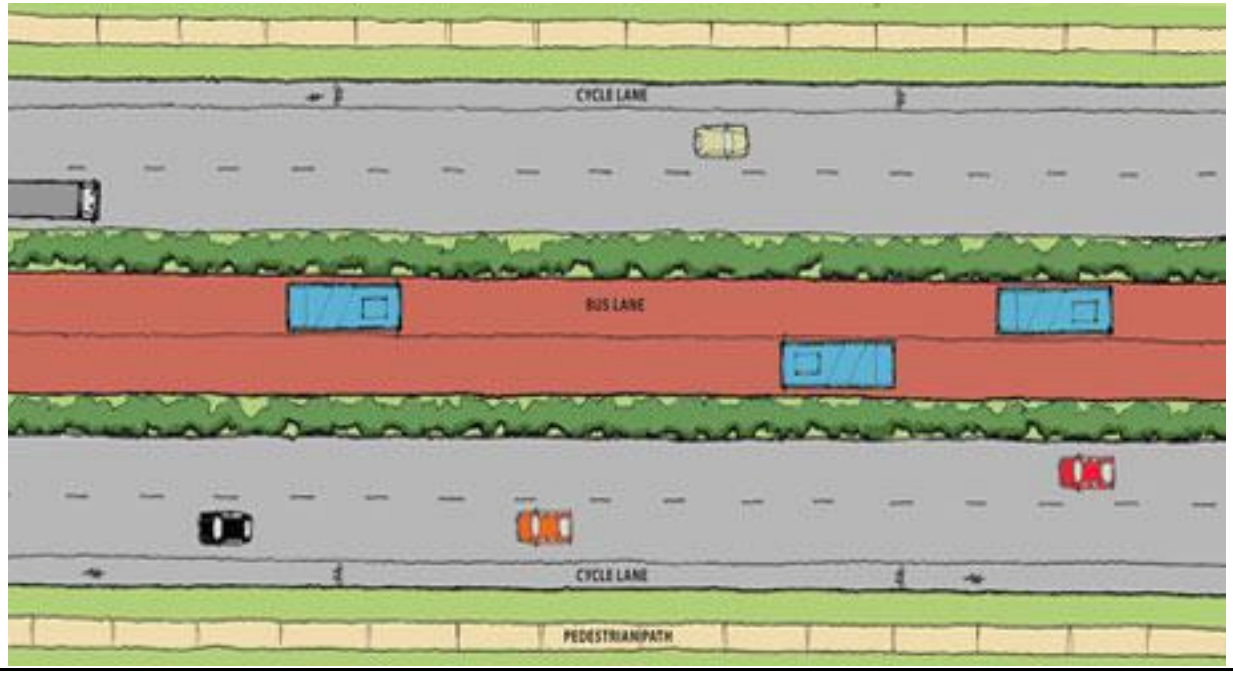
1 Full Physical Segregation of Busways can be achieved through:

In the Delhi context, FULL SEGREGATION of a bus-corridor or busway is possible mostly with *central segregated lanes* only. In rare conditions, fully segregated *kerb-side* lanes are possible with very special design consideration to ensure physical segregation:

a) **Kerb side lanes on either side of the road cannot be *physically segregated* because access from driveways and side-streets must be allowed on to the main road from the edges. This constant interference slows down buses and does not allow for their seamless movement.**

b) In case kerb-side single bus lanes are physically segregated, overtaking during emergency situations would not be possible, in case a bus breaks down, etc.

c) Bus only corridors are a good option for R/Ws that are critical for BRT Connectivity but may be too narrow to accommodate all modes. New corridors constructed can be in the form of Bus-only streets, tunnels, bridges etc. so that addition of more cars to existing roads and consequent congestion can be avoided.

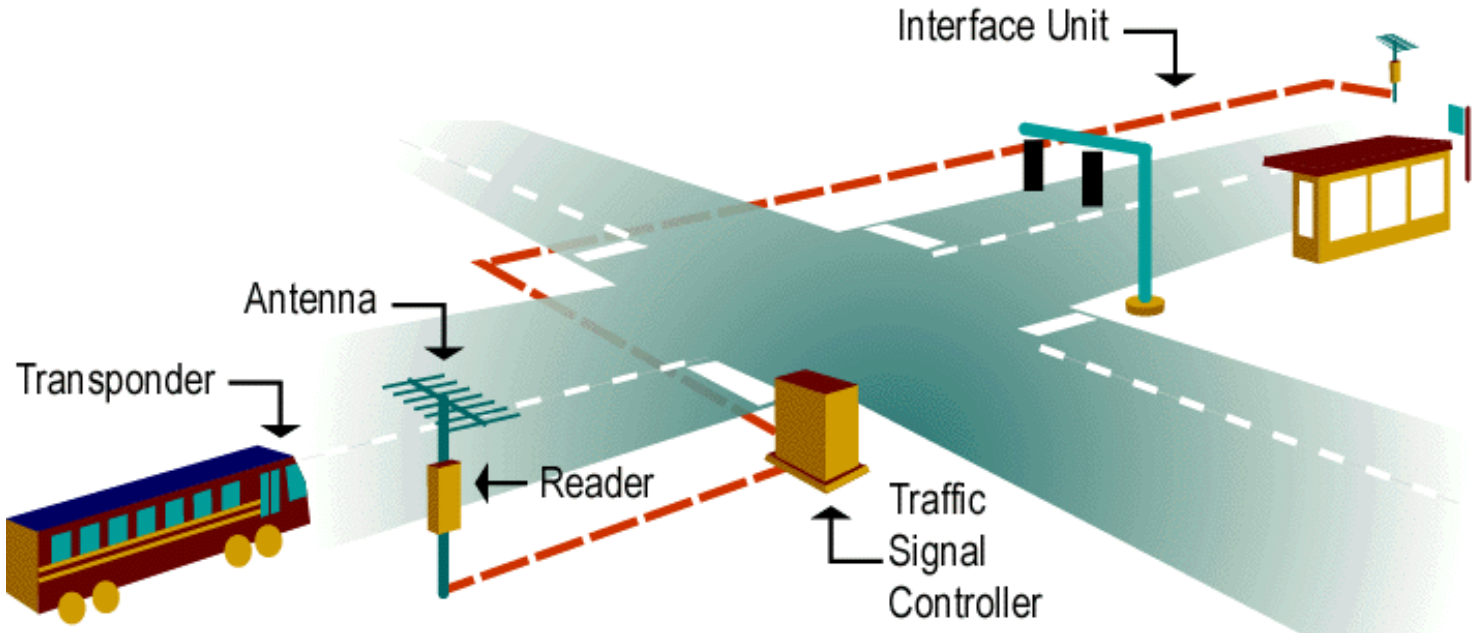


2 Prioritization through Design and Management.

Prioritization is essential for 'taking buses out' of congestion and to make people prefer the use of buses over private vehicles.

Prioritization can be achieved through:

- Use of Intelligent Transportation Systems (ITS) technologies for corridors fully at grade.
- Dedicated bus-only corridors for interference free high-speed movement of people.



Treatment of existing flyover at Ahmedabad.

14A Common Components of BRT Systems:

BRT corridor in Delhi, with dedicated bicycle tracks alongside

3 **Integration with several modes of transport including *other buses, feeder vans, Auto/Taxi, bicycles, cars/two wheelers, pedestrian crossings, cycle rickshaws, and future MRTS,* to ensure quick and easy modal interchange, efficiency and integrated ticketing system.**

Multimodal interchange and Hawker Zones with pedestrian plaza at BRTS corridor Delhi

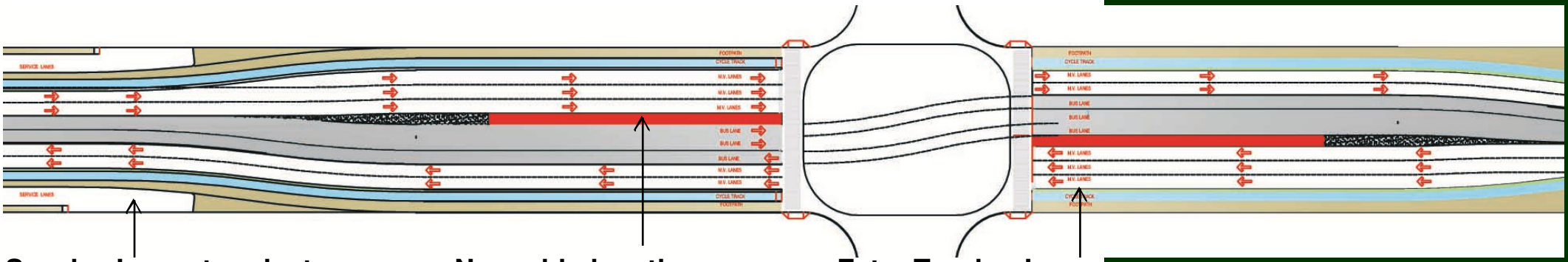
4 **Buses with both-side doors may be required in corridors with median island bus-stops.**

5 **Fleet Selection – Buses must be low-floor as they ensure accessible to all sections of users including old people, children and people on wheelchairs, both within and outside the corridor.**

Special kerb designs for level boarding at BRTS Nantes, France

Pictures: Delhi – S G Architects, Nantes – Karl Fjelsrom, ITDP, www.chinabrt.org

6 Location of the interchange points in relation to the road junctions:

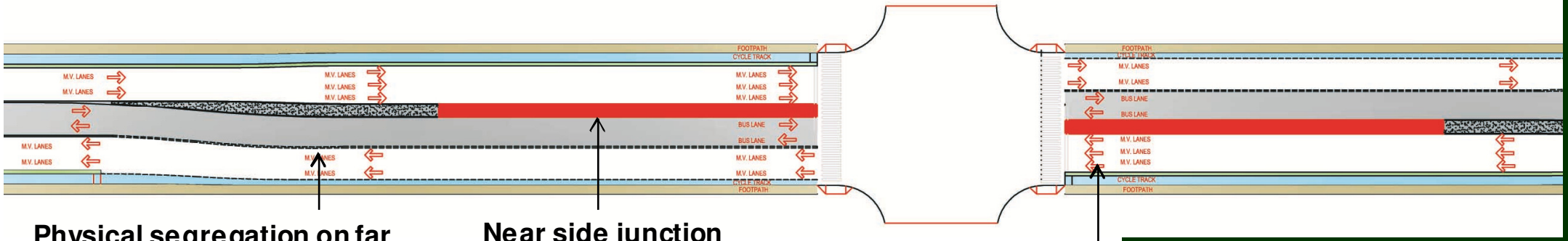


Service Lanes terminates before the junction

Near side junction shelters for higher speed and capacity

Extra Turning Lanes at Junctions

45 m - ROW



Physical segregation on far side set back by 80-100m

Near side junction shelters for higher speed and capacity

Extra Turning Lanes at Junctions

30 m - ROW

☞ **The issue of BRT Stops location and directional interchange at junctions has not yet been resolved by the Working Group.**

The same will be resolved by the Group Members in the forthcoming weeks through various case studies of junctions in Delhi where BRT-BRT Arterial road intersections as well as BRT at existing grade-separated conditions are expected to arise soon.

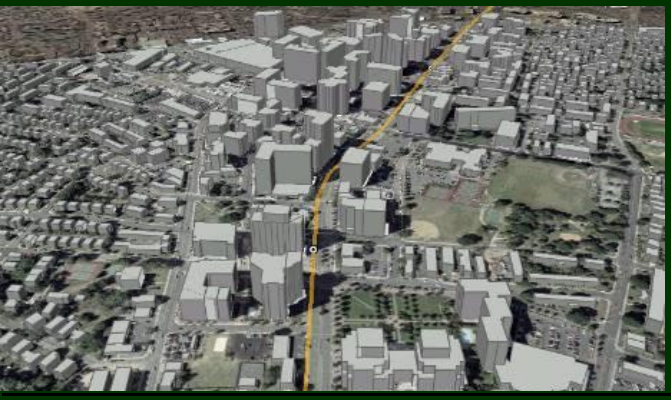
Example Shown above:

- Junction design options showing how bus stops may be accommodated at junctions without any reduction in shared motor-vehicle lanes.
- Extra Left-Turning lanes can be provided at junctions, to reduce waiting time.

Advertisement rights ON Buses/ bus-stops could be a simple and great source of non-farebox revenue and fund source for BRT.

Densification along major BRTS interchanges or terminal stations has many advantages:

- *Maximum people can live-work near BRTS Stations and therefore can easily walk/cycle to BRT.*
- *Increased ridership*
- *Revenue generated can be a good source of non-farebox revenue to fund the BRT.*



14A Common Components of BRT Systems:

7. **Unified agencies should be responsible for Construction, Operations Regulation, Management and Maintenance of the corridors and rolling stock operations.**

8. **Utilization of the land resources, advertisement rights, congestion charges, corridor usage charges, revenue sharing on citations, etc. for financial viability of the road based public transport system/BRT.**

9. **Assurance in removal of encroachment on the RoW and potential increase in density of land-uses for the properties affected by the development.**

The Transportation - Landuse Pyramid (Curitiba BRT):

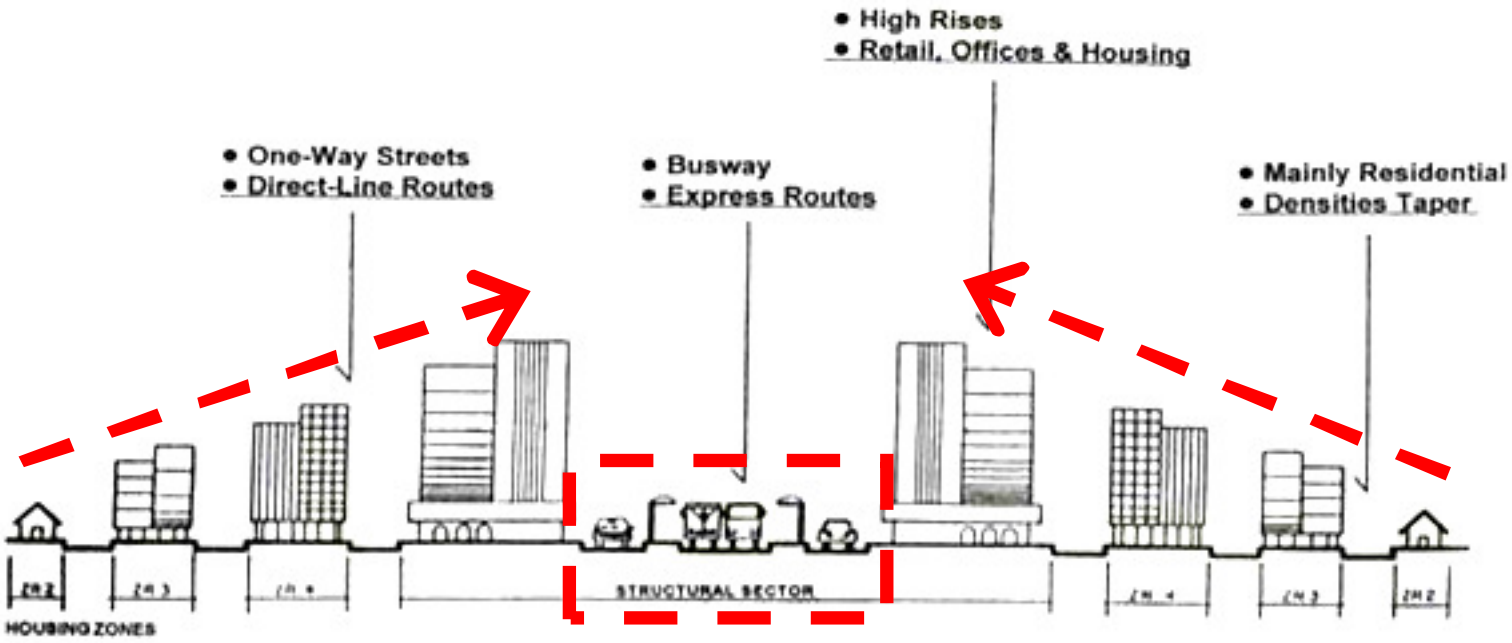


FIGURE 10.2. LAND USES AND DENSITIES ALONG TRINARY ROADS. A cross-sectional perspective. *Source:* Adapted from Instituto de Peisquisa e Planejamento Urbano de Curitiba (IPPUC).

14A Common Components of BRT Systems:

10 **Easy recognition, Imageability and Civic Acceptance:** The image of a BRT discerns it from the local bus system in terms of:

• Special bus-stops • Signage • Signalling • Additional Single fare-box ticketing • Public Outreach/ Awareness Campaign about its advantages - for acceptance by all sections of society.

Screenshot of Janmarg BRTS promotional video

A Janmarg BRTS Poster

જનમાર્ગ
જનમાર્ગ
JANMARG

A distinct, legible and cognizable name and an extensive public outreach campaign helped the success and acceptance of the BRT in Ahmedabad.

Imageable Ahmedabad Bus station

Distinct BRT stations at Curitiba, Brazil

Best Practices

Non separated Carpool lane with the diamond symbol signifying the reservation

Zipper lane (movable concrete barriers) on a Hawaiian interstate freeway.

14.3 HOV Lanes/Carpool Lanes

High-occupancy vehicle (HOV) are reserved lanes used to convey vehicles with four or more occupants.

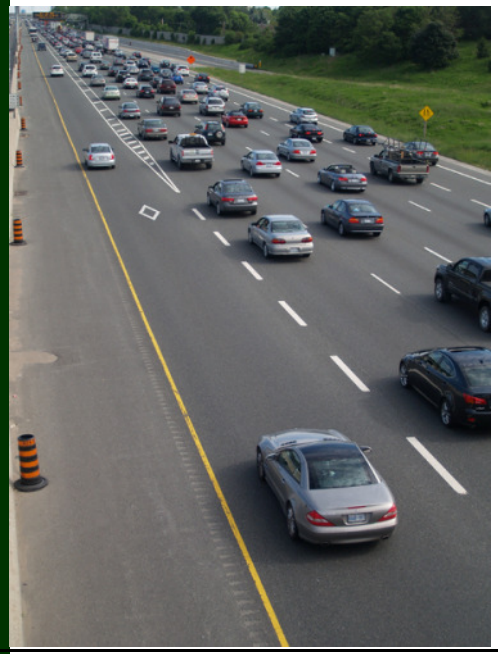
- **HOV lanes can be deployed either only during peak hours or at all times - based on need.**
- **These lanes also allow certain emergency vehicles like ambulances, police cars etc.**

Thrie beams as barrier

Types of HOV lanes:

a) Physically separated - Using concrete barriers, beams, cables, rubber pylons.
   - Concurrent - with the flow of traffic.
   - Contra-flow - against the flow of traffic as extra lane during peak hours with movable barriers.

a) Buffer separated - Buffer is a painted neutral area between HOV lane and normal lanes.
b) Non separated - without any physical separation except a coloured line.



Buffer separated HOV lanes in Greater Toronto, Canada

<u>Contra flow HOV lane</u> in M27 Motorway at Hampshire, England

14.4 Bus Only Corridors

Bus-only corridors: are corridors which only allow buses and emergency vehicles (with NMV and pedestrian provisions) to ply on them either during certain hours or the entire day.

Need for Bus-only corridors:

- Where high capacity people movement is required and corresponding infrastructure costs are high.
- Core city areas where space is a constraint.

Types of Bus-only corridors:

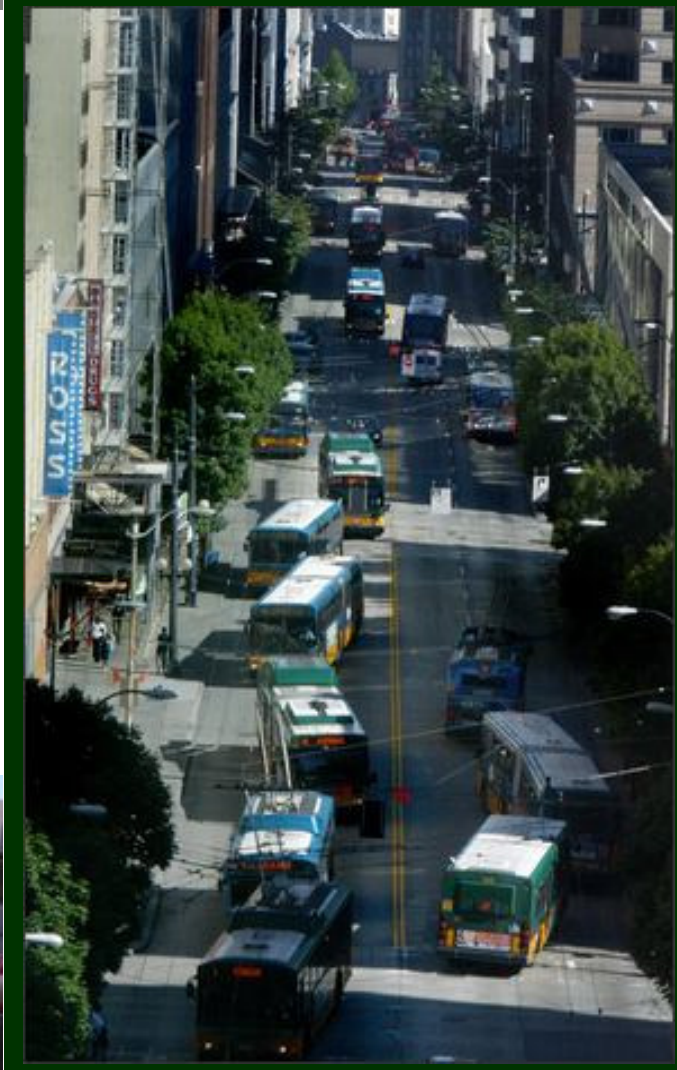
a) **Bus-only streets:** Bus streets are entire streets reserved primarily for public transport vehicles along with pedestrians and NMT.
   - IPT and all par transport including autorickshaws, cycles and cycle-rickshaws may be allowed in addition to buses.
   - Provision for off-hour deliveries can be given.
   - All provide emergency vehicle access.

b) **Bus-only bridges:** are bridges reserved for public transport.

Nicolett Street transit mall, Minneapolis with extra wide sidewalks created by removing through lanes.

Bus only road at Westboro , Ottawa, Canada

Best Practices



Bus only street at third avenue, Seattle, USA with provision for pedestrians

14.5 Guided Busways

Kerb guided busway at Cambridge UK

View of Guiderail

View of kerb Guide wheel

Guided busways: are running ways on which buses are steered for part or their entire route by external means, usually on a dedicated track.

Need for Guided busways:

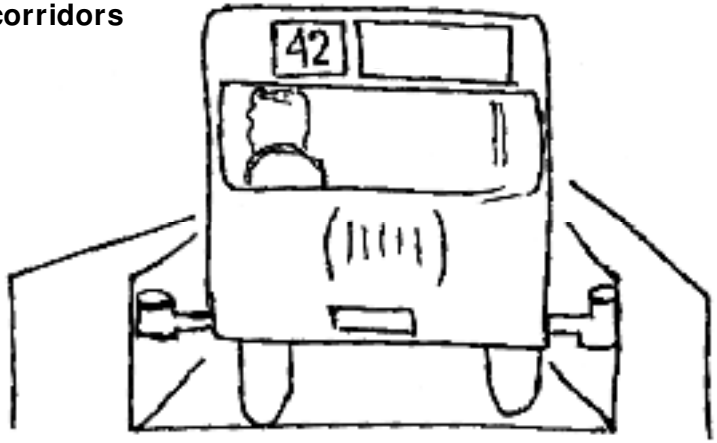
- **Reduction in required running way (approx. 2.6m from 3.1-3.5)**
- **Accessible bus stops with no gap between bus & platform.**
- **Use of track for storm water management.**

Types of Guided Busways:

a) **Kerb Guided Busways: These are a form of mechanically guided busway system where a track wheel is used to guide the bus by running along the kerb.**
b) **Optical Guided Busways: These are a form of optically guided busway system where an optical tracking device is used to guide the bus along the route.**

Applications: This system can be used for

- **Streets with limited ROW**
- **Ecomobility corridors**
- **Railway Easement running ways for guided buses.**
- **Bus-only corridors**
- **BRT corridors**



Cartoon showing Guided Bus Section
Source: camcycle.org.uk

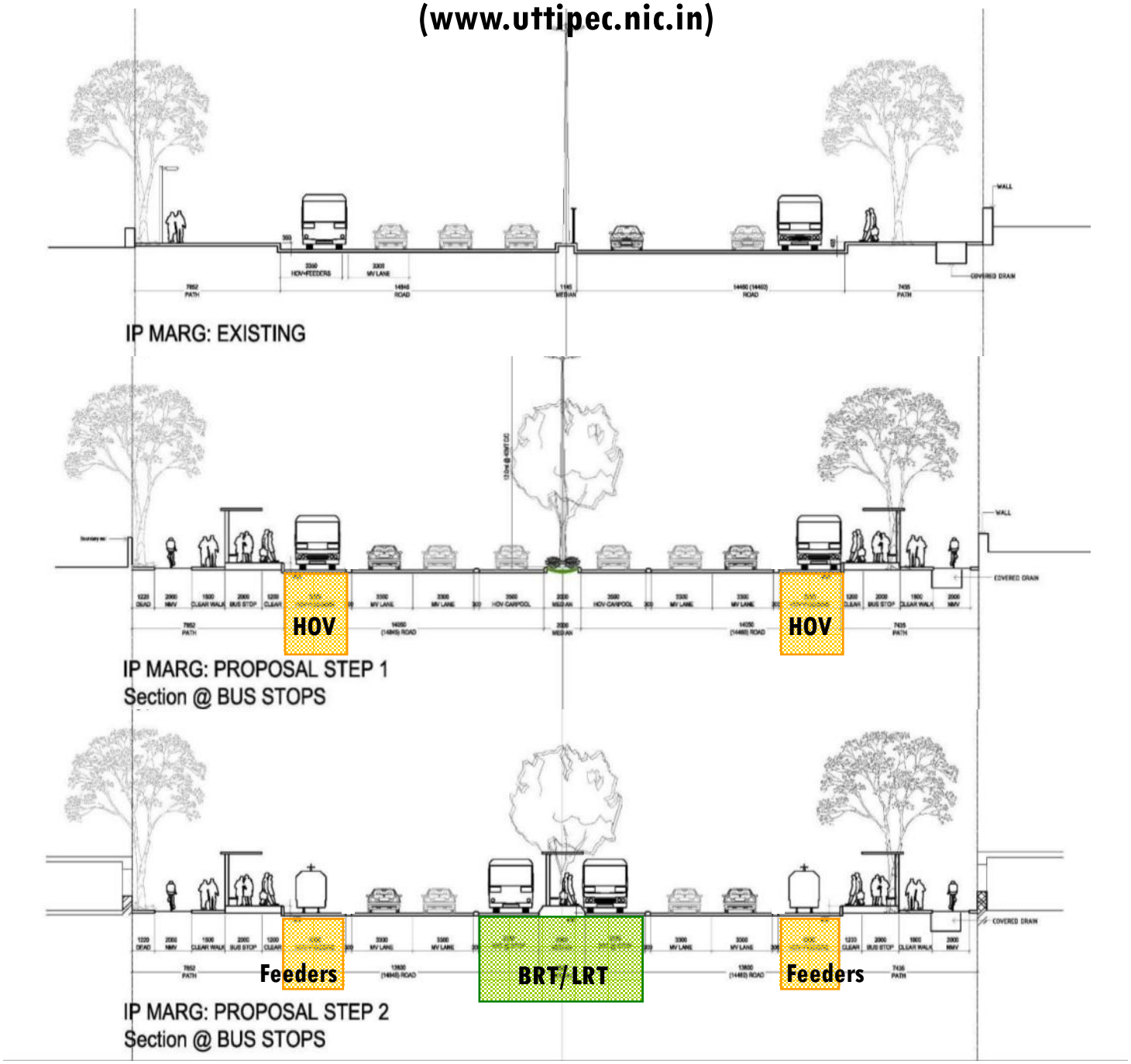
Montage of Guided busways in Essen, Germany

Optical guiding device on bus in Rouen,

Guided busway along NMV track in Germany

Case Study: ITO : I P Marg. 45m R/W.

(www.uttipec.nic.in)

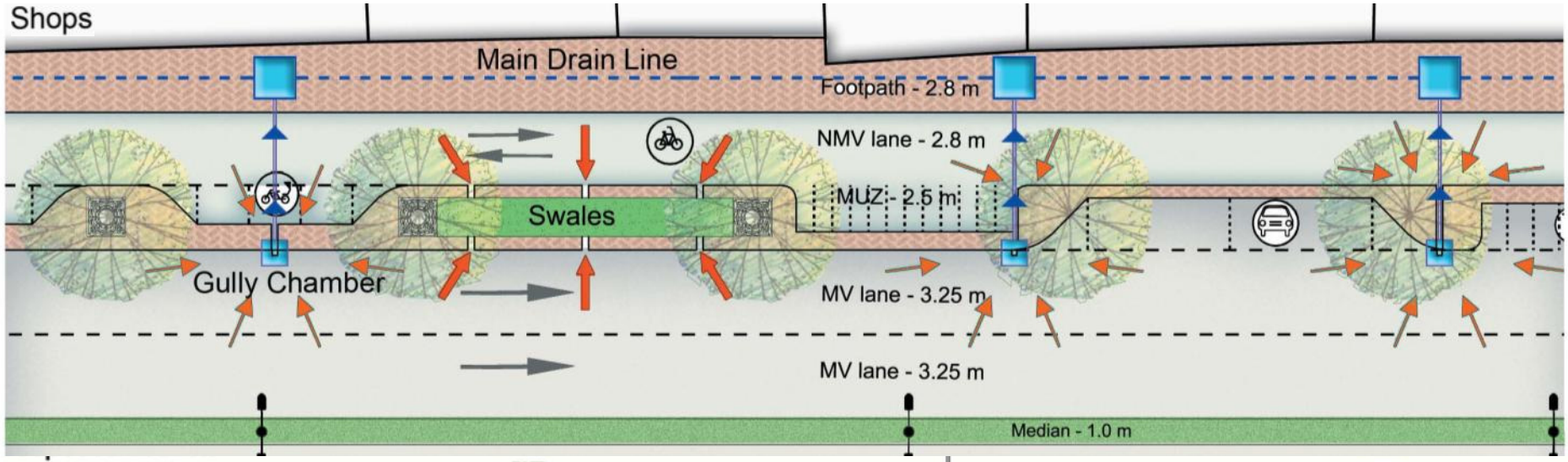


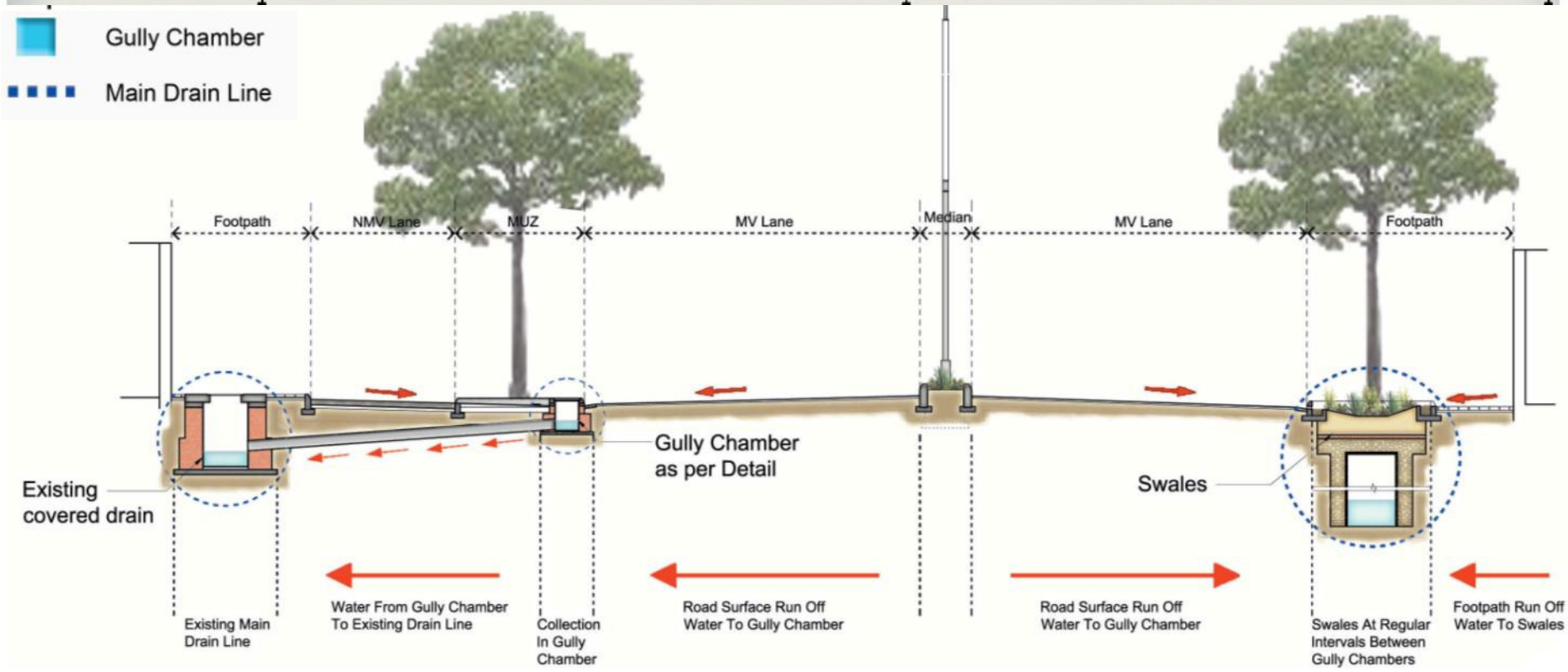
Existing State

IP Marg at ITO, Delhi

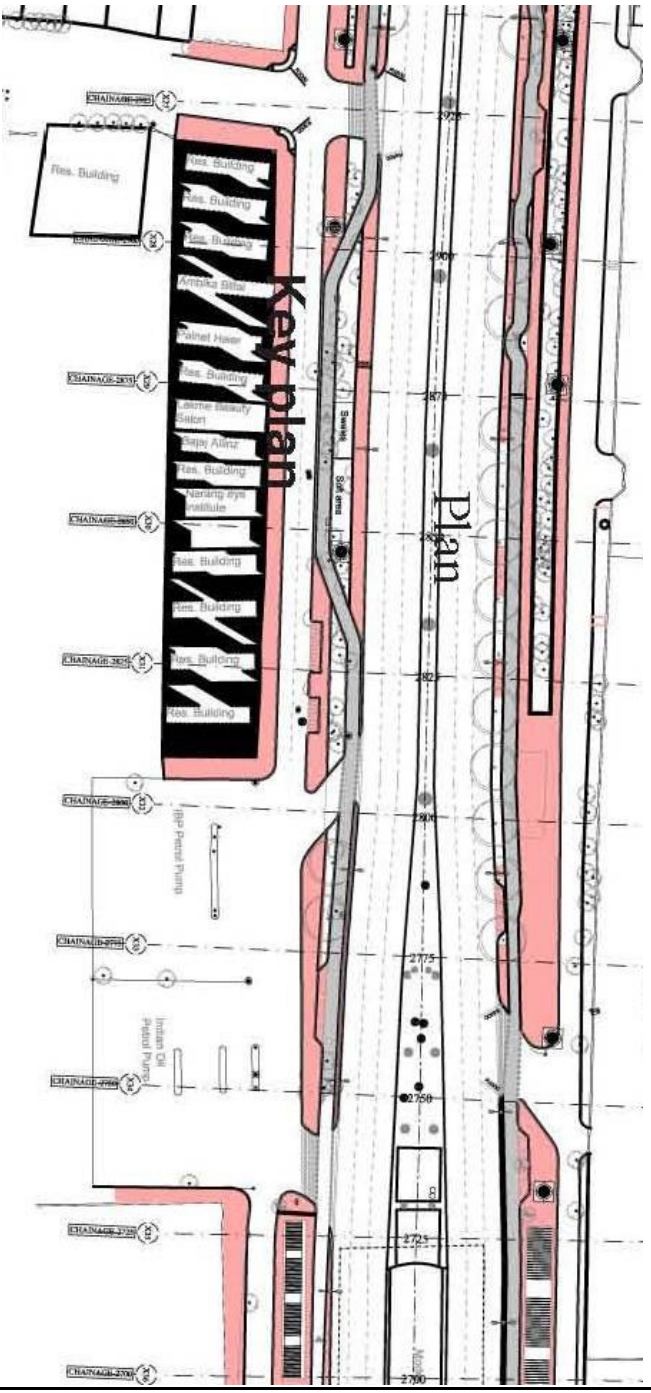
Annexure - I

Typical Street-edge Plan showing flow of surface (rain) water into Swales – from the carriageway as well as the footpaths/ cycle tracks.





Annexure - I



Water Management calculations for 500 metres road: Delhi University area, Grid X20 to X41

		width	length	area(sqmt)			
1.00	Road area/ paved area, (six MV lanes of 3.25mts+ 2 nos NMV lane of 2.6 mts and 2nos Foot path of 3.0 mts)	30.7	500	15350			
2.00	Semi soft areas, (median, MUZ etc)	7	500	3500			
3.00	volume of water received from roads	15350	0.6	9210	Cumt		
	area of catchment x amount of rain fall (0.6m in Delhi)						
4.00	volume of water received from median and MUZ	3500	0.6	2100	Cumt		
5.00	assuming 70% of rain water from roads is available for harvesting			6447	Cumt	6447000	lts
6.00	assuming 30% of rain water from MUZ is available for harvesting			630	Cumt	630000	lts
7.00	Total water available for Harvesting **(A)**			7077	Cumt	7077000	lts
8.00	On a thumb rule, one Harvesting Pit can recieve rain water from 200 sqmts of road area. (as per CSE study in DU area)	200	0.6	120	Cumt	120000	lts
9.00	Number of rain water harvesting pits required to Discharge 7077 KL rain water			58.975			
	say			**60**			
	Recharge pit Calculations						
	Delhi peak rainfall per hour	90	mm				
	Peak rainfall for 15 minutes	22.5	mm	0.0225	mts		
	max catchement area per Recharge well = 200 sq r	200	sqmt				
	Runoff coefficient	0.7					
	Size of the pit = catchement areaxPeak rain fall for 15 mins x runoff coefficient	3.15	cumt				
	Size of Rain water Recharge Holding pit	1.5x1.5x1.4	mts				

Sample Calculations for Water Management/ Rain Water Harvesting on Streets

Source: Pradeep Sachdeva Design Associates, Nov 2009

Annexure - II

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Abbreviations:

NMT : Non Motorized Transport
NMV : Non Motorized Vehicle
MV : Motorized Vehicles
MRTS : Mass Rapid Transport System
BRTS : Bus Rapid Transit System
IRC : Indian Road Congress

DDA : Delhi Development Authority
MOUD : Ministry of Urban Development
ICE: Interface for Cycling Expertise
TRIPP: Transport Research and Injury Prevention Programme
GHG: Green House Gas

Note: The term "Kerb" used in the document could also be referred to as "Curb".

Annexure - III

Members of WORKING GROUP I-A (DEVELOPMENT OF PLANNING GUIDELINES)

S.No.	List of officers	Designation/Office Address
1.	Sh. Sanjiv Sahai	MD (DIMTS), Chairman
2.	Sh. Ashok Kumar	Commr.(Plg.) DDA, Co-Chairman
3.	Sh. J.B. Kshirsagar	Chief Planner- Town & Country Planning Organization (TCPO),Member.
4.	Sh. V.K. Bugga	Chief Town Planner, MCD, Member
5.	Sh. R P Indoria	Secretary General, Indian Roads Congress (IRC), Member
6.	Sh. S. Gangopadhaya	Head (T&T)- Central Road Research Institute (CRRI), Member
7.	Sh. Kumar Keshav	Director (Projects)- Delhi Metro Rail Corporation (DMRC), Member
8.	Dr. Ashok Kumar Saroha	Director (Urban Transport), MOUD, Member
9.	Representative	Ministry of Surface Transport (GOI), Member
10.	Sh. R.S. Minhas	Sr. Manager (Tr.) – Delhi Transport Corporation(DTC), Member
11.	Sh.Rakesh Mishra	Engineer – in – Chief, PWD, Member
12.	Sh. Ravi Dass	Engineer – in – Chief, MCD, Member
13.	Sh. V.L. Patankar	Member (Technical), National Highway Authority of India, (NHAI)Member
14.	Sh. Vijay Anand	Chief Engineer (Const.) – Northern Railway, Member
15.	Sh. Satyendra Garg	Jt. Commr. Of Police (Traffic)-GNCTD, Member
16.	Sh. Rohit Baluja	President – Institute of Road Training Education(IRTE), Member
17.	Sh. Pavan Gupta	Consultant – Institutional System Planning Centre,(ISPC) Member
18.	Smt. Sunita Narain	Director – Centre for Science and Environment(CSE), Member
19.	Sh. S.S. Mathur	Ex. Secretary General ,Nominee of Secretary – ITPI, Member
20.	Sh. B.S. Diwan	Secretary – Institute of Urban Transport Member(IUT)
21.	Sh. Ramesh Raina	Chief Engineer – New Delhi Municipal Council (NDMC), For Engineer in Chief, Member
22.	Sh.N.R.Aravind	Deputy Director(Plg) UTTIPEC, convener

Annexure - III

Planning for Pedestrians – Design Guidelines: Sub Group Members:

1. Sh Sharad Varshney, Addl. (Dir.) Technical, IRC (Nominated)
2. Sh. R.Shri Niwas Associate Town & Country Planner (TCPO) (Nominated)
3. Sh. P.S. Uttarwar, Dir.(Plg.)UC, DDA
4. Ms M.Z. Bawa, Director(Plg.) MPPR,DDA
5. Sh. Simon Bishop, Consultant, DIMTS
6. Sh. Pradeep Sachdeva, Architect, Consultant
7. Ms. Anjlee Aggarwal, Executive Director, Samarthyam
8. Ms. Romi Roy, Sr. Consultant, UTTIPEC
9. Sh. Ashok Bhattacharjee, Director (Plg) UTTIPEC
10. Sh. N. R. Aravind, Deputy Director (Plg.) UTTIPEC, Convener
10. Nominated members of MCD, PWD, NDMC, Traffic Police

Special Invitees : (Contributors)

1. Sh. B. K. Jain, A.C. (Plg.) TC&B, UTTIPEC DDA
2. Sh. Ashok Bhattacharjee, Director (Plg.) UTTIPEC
3. Sh. Pramod Behera, Jt. Dir. (Plg.) UTTIPEC
4. Sh. Sabyasacchi Das, Dir (GIS & Website)
5. Sh. Sandeep Gandhi, SG Architects, Consultant
6. Sh. Akash Hingorani, Oasis Designs, Consultant
7. Ms. Anumita Roy Choudhary, Associate Director, CSE
8. Dr. Anvita Arora, Transport Planner

Others:

1. Sh. A.K. Saini, A.D.(Plg.)UTTIPEC
2. Sh. Jeevan Babu, Planning Assistant, UTTIPEC

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In case of all the pedestrian facilities, the issue of regular upkeep and maintenance is vital. Road owning agencies may need to formulate a regime to ensure regular upkeep of footpath surfaces, lighting, signage, amenities, etc.

To involve the local community in the maintenance and upkeep, innovative approaches of financing the upkeep and maintenance of roads need to be explored.