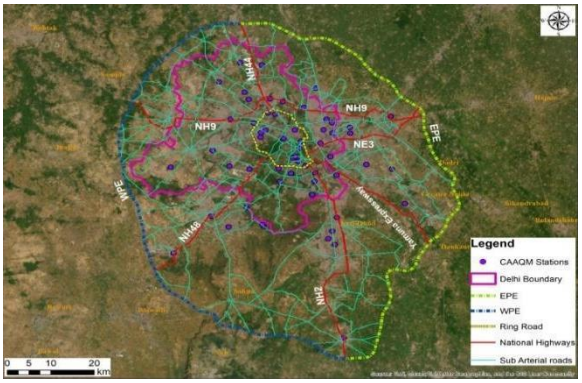
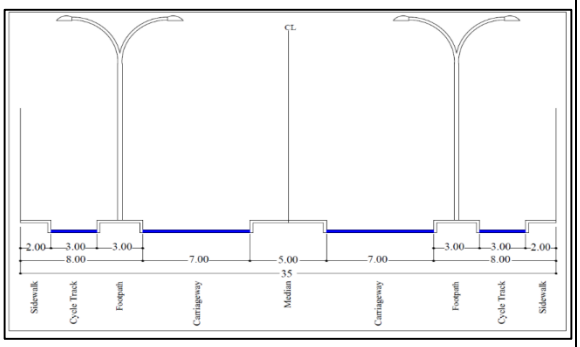
# Committee Report on

# Standard Framework for Controlling Dust Pollution from Roads in Delhi NCR

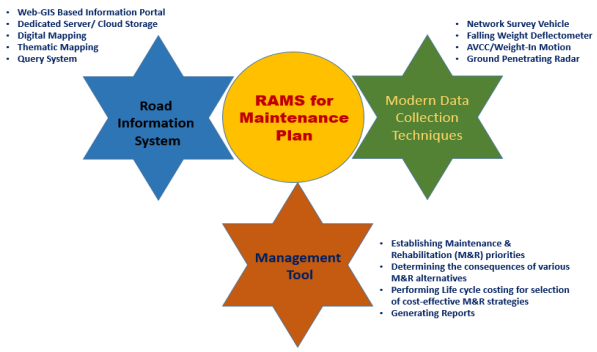
## Report-1 on "Standard Framework for Paving and Greening of Urban Roads"

**Commission for Air Quality Management in NCR and Adjoining Areas**








# January 2025

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# Chapter 1 INTRODUCTION

## 1.1 Background and Need for the Framework

The National Capital Region (NCR) of Delhi is one of the fastest-growing urban regions in India, with a population exceeding 32 million as of 2023 (NCRPB, 2023). Rapid urbanization and a decadal population growth have intensified infrastructure demands, contributing to environmental challenges, including dust pollution and air quality degradation. The NCR of India, encompasses the entirety of the National Capital Territory of Delhi (NCT-Delhi) and selected districts in the neighbouring states of Haryana, Uttar Pradesh, and Rajasthan. The total area covered by the NCR is about 55,083 $km^2$, this includes 1,483 $km^2$ from NCT-Delhi, 25,327 $km^2$ from Haryana, 14,826 $km^2$ from Uttar Pradesh, 13,447 $km^2$ from Rajasthan (National Capital Region Planning Board, 2018). The NCR of Delhi faces severe environmental challenges, particularly dust pollution caused by open areas, and ongoing construction activities. Rapid urbanization and infrastructure development have led to the increase in impervious surfaces, loss of green cover, and unplanned open spaces, exacerbating air pollution, urban heat island effects, and waterlogging. Dust generated from open surfaces contributes significantly to particulate matter ($PM_{10}$ and $PM_{2.5}$) levels, worsening air quality and posing serious health risks to residents. The strategies to address this problem have to be diverse and not limited to only road cleaning and sweeping. A lot of this problem is also created by mismanaged urban road constructions and their maintenance/ repairing requirements/ protocols.

The 2019 National Clean Air Program (NCAP) emphasized infrastructure improvements and systematic urban design to mitigate air pollution. Key provisions included the repair and construction of pavements, implementation of street design guidelines for cross-sectional elements such as carriageways, footpaths, cycle tracks, adequate buffers, and road shoulders. Measures also involved blacktopping of roads, paving of road shoulders, installation of water fountains at major intersections, ensuring pothole-free roads, increasing green cover on central verges, and enhancing roadside greenery along the right-of-way (ROW). Additionally, the plan called for the strict enforcement of air pollution control measures.

During the winter of 2021-22, the Commission for Air Quality Management (CAQM) issued further directives and advisories to control dust pollution during smog episodes (CAQM Report, 2022). The report outlined long-term, systematic changes, including the development of street network plans incorporating paving and greening in alignment with IRC guidelines. It also advocated for a greening agenda targeting open spaces in the NCR. Furthermore, the report

provided a targeted action plan, specifically addressing dust control measures for roads and ROWs, reinforcing the need for comprehensive, sustainable urban practices (CAQM, 2022).

Recognizing the need, a collaborative study was undertaken by CSIR-NEERI and CSIR-CRRI in year 2023-24, with support from the CAQM, on "*Addressing Vehicular Traffic Induced Road Dust Re-Suspension with S&T based Action Plans for Air Quality Improvement in Delhi NCR*". This study quantified re-suspension of road dust over a selected road stretch in NCT Delhi. The report suggested effective control measures to mitigate re-suspended road dust pollution which include strategies to reduce dust generation, such as paving unpaved shoulders and medians and creating green spaces, as well as techniques to lift dust from roads using mechanical and manual methods. This study proposed actionable solutions for mitigating road dust re-suspension. The study encompassed road network mapping, pollution assessment, and control strategy recommendations. The findings of this study emphasize the urgent need for standardized interventions to curb road dust re-suspension:

1. Road Design and Maintenance: Surveys of major road stretches revealed poor maintenance and dust accumulation, especially along road edges and medians. Enhanced design and regular maintenance can significantly reduce dust generation.
2. Vegetative Barriers and Greening Initiatives: The integration of green spaces along roads has shown promise in stabilizing loose soil and acting as a natural barrier to dust propagation. A three-tier plantation system with selected plant species can further enhance air quality.
3. Innovative Dust Management Techniques: A detailed Standard Operating Procedure (SOP) was developed for applying dust suppressants, with a focus on cost-effective and environmentally friendly materials.

This above study also suggested to develop a unified framework for paving and greening urban roads in Delhi NCR is crucial to ensure consistent implementation of best practices. The report also recommended that the framework includes Standardized Road Paving Guidelines, Greening Urban Roads, Integrated Dust Management Strategies, and Monitoring and Accountability Mechanisms. Such a framework, rooted in scientific analysis and practical solutions, is expected to enhance road infrastructure but also contribute significantly to air quality improvements.

To address these challenges, there is an urgent need for a comprehensive framework that focuses on sustainable paving and systematic greening of NCR Delhi. Paving open and unpaved surfaces using eco-friendly, permeable materials can help control dust emissions, reduce surface runoff, and facilitate groundwater recharge. Simultaneously, enhancing green cover through urban greening

initiatives, such as tree plantations, green buffers, and landscaped open spaces, will act as a natural dust barrier, improve air quality, and provide thermal comfort.

## 1.2 State of Art on Road Dust

The re-suspension of road dust is influenced by continuous dust deposition at the edges of road medians, unsuitable road infrastructural designs including poor road design and maintenance of insufficient and staggered dust management practices. The National Air Quality Index of India considers Particulate Matter PM (PM10 or PM2.5) in ambient air as an essential pollutant for its calculation. Being the critical pollutant for air quality in Delhi city, it is necessary to reduce the PM levels in the city as well as in surrounding areas.

Earlier studies for Delhi/NCR reported that the contribution of road dust re-suspension was very high (Sahu et al. 2011; Guttikunda and Calori 2013; Gargava et al. 2014; Sharma and Dikshit 2016; ARAI 2018; SAFAR 2018; Singh et al., 2020; Sahu et al. 2023)and was responsible for increased $PM_{10}$ and $PM_{2.5}$ concentration (NEERI, 2010; IIT Kanpur, 2016; TERI-ARAI, 2018). The contributions of road dust re-suspension reported in these studies are summarised in Table 1.1.

**Table 1.1: Review of past studies on road dust re-suspension contributions in overall PM emission load in Delhi**

| Source Apportionment Study for Delhi city | Total Emission Load from all sources(t/d) | Road Dust Contribution (%) |
|---|---|---|
| NEERI, 2010 | $PM_{10}$ = 147<br>$PM_{2.5}$ – N/A | $PM_{10}$ = 52% i.e., 77 t/d<br>$PM_{2.5}$ – N/A |
| IIT Kanpur, 2016 | $PM_{10}$ = 143.4<br>$PM_{2.5}$ = 58.7 | $PM_{10}$ = 56% i.e. 79.6 t/d<br>$PM_{2.5}$ = 37.6% i.e., 22.1 t/d |
| ARAI and TERI, 2018 | $PM_{10}$ = 186.3<br>$PM_{2.5}$ = 87.6 | $PM_{10}$ = 35.2 % i.e., 65.7 t/d<br>$PM_{2.5}$ = 18% i.e., 15.8 t/d |

Denby et al. (2019) reviewed road dust emissions in diverse environments, including Nordic countries, and highlighted the influence of local traffic, meteorological, and environmental conditions. They emphasized the lack of standardized methods for road dust measurement, complicating comparisons across regions. Gustafsson et al. (2015) examined road dust measurement techniques in Sweden and Norway, underscoring the need for intercomparison of wet and dry sampling methods to improve accuracy.

Future research should focus on standardized measurement protocols, integrated data collection from multiple agencies/ departments, and evaluation of dust mitigation strategies for effective PM pollution reduction. The resuspension of road dust is influenced by continuous

dust deposition at the edges of road medians, unsuitable road infrastructural designs including poor road design and maintenance, insufficient dust management practices etc.

The paving and greening framework is crucial for mitigating dust pollution, improving environmental health, and fostering sustainable urban development. It will serve as a guideline for policymakers and urban planners to strike a balance between infrastructure growth and ecological preservation, ensuring a cleaner and healthier future for NCR Delhi.

### 1.3 Objectives and Scope of the Framework

The primary objective of the framework is to mitigate dust pollution caused by mismanaged urban construction and roads in Delhi NCR through sustainable paving and greening solutions. The framework aims to provide guidelines for designing and managing Right of Way (ROW) across various road categories, including expressways, arterial, sub-arterial, and collector roads by incorporating eco-friendly pavements and green infrastructure.

The scope of this report includes identifying effective paving designs, methods and materials to control dust emissions, enhancing green cover through tree plantations and landscaped buffers, and promoting the use of permeable surfaces to address dust and waterlogging issues. This framework focuses on improving air quality, environmental health, and urban aesthetics.

### 1.4 Composition of the Committee

The task of developing a framework for controlling dust pollution from roads and open areas was undertaken by a committee constituted by the Commission for Air Quality Management (CAQM) in National Capital Region (NCR) and adjoining areas vide its Office Order F.No. A-110012/08/2020/CAQM-RD-1107/DT dated 21/11/2024 (Annexure-1).

The composition of the Committee is as under:

1. Prof. Manoranjan Parida, Director, CSIR-CRRI, New Delhi - Chairman
2. Dr. S.K. Goyal, Chief Scientist, CSIR-NEERI, New Delhi - Member
3. Dr. Bidisha Chattopadhyay, Ass. Professor, SPA, New Delhi - Member
4. Dr. K.S. Jayachandran, Member Secretary, DPCC - Member
5. Dr. Jagan Shah, CEO, The Infravision Foundation, Delhi - Member
6. Dr. Vikash Singh, Scientist - E, CAQM - Convener

The Terms of Reference of the Committee are as under:

(i) Analysis of existing problems related to dust pollution from roads and open areas.

(ii) Review of existing studies, including ongoing studies by CSIR-National Environmental Engineering Research Institute (NEERI), Delhi and CSIR-Central Road Research Institute (CRRI), Delhi on Addressing Vehicular Traffic Induced Road Dust Re-suspension with S&T based Action Plans for Air Quality Improvement in Delhi NCR.

(iii) Feedback from different stakeholders regarding the issues at hand.

(iv) Developing a standard framework for controlling dust pollution from roads and open areas addressing issues gathered from (i), (ii) and (iii) above.

The aforesaid Committee had several meetings, including meetings with Chairperson, CAQM and other senior officials of CAQM and multiple stakeholders. List of meetings held by the Committee is as under:

| S. No. | Date | Subject | Remarks |
|---|---|---|---|
| 1 | 06.12.2024 | Committee meeting on controlling dust pollution from roads and open areas | Participant list in Annexure-2 |
| 2 | 09.12.2024 | Framework development for paving and greening areas at CSIR-CRRI | Participant list in Annexure-2 |
| 3 | 13.12.2024 | Committee meeting on controlling dust pollution from roads and open areas | Participant list in Annexure-2 |
| 4 | 17.12.2024 | Discussion on GIS database for Delhi PWD Road Network at CSIR-CRRI | Hybrid meeting; Participant list in Annexure-2 |
| 5 | 20.12.2024 | Committee meeting on controlling dust pollution from roads and open areas | Participant list in Annexure-2 |

### 1.5 Feedback from Stakeholders

A list of the various officials and stakeholders involved in the discussion is annexed as Annexure 2. The inputs and suggestions received during these meetings are summarised below. As per the discussions held with CAQM, the report is to be prepared in multiple phases. The first Report will focus on the "***Standard Framework for Paving and Greening of Urban Roads***" while the second report will address the "***Mechanised Road Sweeping framework for Urban Roads and Open Areas"***.

i. **Dust Suppressants**: Dust suppressants should be applied only in open areas of medians and road edges where vehicle tire movement is minimal. It should be the last resort for controlling dust and re-suspension of dust on roads.

ii. **Mechanised Road Sweeping Machines (MRSM) Operation:** Ensure sufficient numbers of MRSMs for routine cleaning and emergencies, operating during off-peak hours. The number of MRSMs required for effective dust control depends on road network size, traffic density, sweeping frequency, and available resources. On an average One MRSM typically covers 35-40 km per day based on road conditions

iii. **Anti-Smog Guns (ASG)**: ASG should be deployed selectively on high priority situations. Deploy Anti-smog guns (ASGs) is recommended in emergency or construction zones. ASGs should be considered a lower priority for dust control on roads. ASGs should be considered a supplementary tool and not the primary method for road dust control, as MRSM

iv. **Pothole Repair**: No data available for the quantity of material used in pothole repair and generally, manual method is used. Multiple pothole repair machines using cold mix technologies (as per IRC SP 100 with 9.5 mm Nominal Maximum Aggregate Size (NMAS)) can be deployed in different PWD zones to efficiently complete the pothole maintenance work, progression of size of pothole and controlling subsequently large amount of dust being generated due to unmaintained potholes on urban roads.

v. **Maintenance of Median and Footpath plantation:** Dust from unpaved medians blows onto the roads. The hose pipes used for irrigation of the median and the footpath plantations is of thick diameter spilling the soil onto the carriageway. Initiate Integrated Maintained Contract for Roads including Maintenance of Green Portion of ROW of Roads

vi. **Manual Cleaning**: In areas where MRSMs are ineffective (e.g., tight spaces or where access is obstructed), manual cleaning plays a significant role in dust control.

vii. **Encroachment**: Unauthorized parking and road encroachment can obstruct cleaning operations, exacerbate dust accumulation, and make it difficult to implement dust suppression measures. This needs to be addressed for effective dust control.

viii. **Decision Support System (DSS):** Accelerate next stage of DSS, integrating source apportionment data and the 18,000 km road network. Integrate administrative geography and jurisdictional overlaps with central agencies and make the system year-round. Integrate Delhi Road Asset Management System with air quality data.

ix. **Complete Street Guidelines**: Fast-track order requiring road-owning agencies to develop full cross-sections of ROW with green buffers and ensure effective monitoring and enforcement of guidelines.

x. **C&D Waste Management**: Prioritize planning for C&D waste management with extended timelines. More collection sites needed, alongside crushing/recycling facilities.

xi. **Road Dust Reduction**: Explore scaling of road engineering and construction technologies for dust reduction and implement mechanized pothole repair at scale through bulk procurement.

xii. **Lifting of Road Dust:** Determine if dust needs to be transported or can be managed on-site. If transport is needed, ensure vehicle availability and quick turnaround.

# Chapter 2 URBAN SPACE STANDARDS AND CROSS SECTION ELEMENTS

## 2.1 Introduction to Urban Roads

Urban road planning, design, and management play a pivotal role in shaping the mobility, safety, and liability of cities. In an era of rapid urbanization and increasing vehicular demand, creating efficient and sustainable road networks has become a critical challenge for urban planners, policymakers, and engineers. Addressing this challenge requires comprehensive guidelines that consider the unique characteristics of urban environments, including high population densities, diverse road user needs, and environmental concerns. The Urban Roads Manual (URM) (IRC: SP:128-2020) serves as a vital resource, providing a guiding framework for urban road design and management tailored to Indian cities. The URM adopts a holistic approach, encompassing the planning, design, construction, and maintenance of urban roads to achieve the dual goals of enhanced mobility and sustainability. The manual is meticulously crafted to address key focus areas such as space allocation, cross-section design, intersection planning, and road safety elements. By integrating principles of sustainability, the URM emphasizes pedestrian-friendly designs, green infrastructure, and the incorporation of smart technologies to create modern and efficient urban road networks

The URM is structured to provide actionable and scalable guidelines for urban road development. Its focus on critical aspects ensures the delivery of high-quality road infrastructure that meets the evolving needs of urban areas. Among its notable features are:

- **Comprehensive Guidelines:** The manual offers detailed standards for planning, designing, constructing, and maintaining urban roads, ensuring a consistent approach to urban road development across diverse contexts.
- **Space Standards and Cross-Section Design:** It emphasizes optimal space allocation, ensuring equitable distribution of road space among vehicles, pedestrians, cyclists, and other users.
- **Intersections and Safety Elements:** Detailed guidance on intersection design and the integration of safety features helps reduce accidents and improve overall road user experience.
- **Integration of Sustainability:** By promoting pedestrian-friendly environments, green infrastructure, and the use of smart road technologies, the URM aligns with global best practices in sustainable urban development.

## 2.2 Road Classifications

The classification of urban roads is essential for understanding their function and role within the broader transportation system. Roads in urban areas are classified based on functions and factors such as traffic volume, speed, and their role in connecting different areas of the city. The Indian Roads Congress (IRC) has developed a classification system for urban roads that considers these factors and provides specific design criteria for each road class.

i. **Urban Expressways**: High-speed highways connecting inter-city roads and expressways to city-specific locations.
ii. **Arterial Road**: Main roads facilitating city-wide mobility and access to distant destinations.
iii. **Sub-Arterial Road**: Secondary roads offering through traffic with lower mobility than arterial roads.
iv. **Collector Street**: Routes for gathering and distributing traffic between local streets and larger roads.
v. **Local Street**: Streets providing direct access to residences, businesses, and adjacent properties.
vi. **Non-Motorized Transport (NMT) Streets**: Restricted to non-motorized vehicles, with barriers ensuring no motor traffic.

## 2.3 Space Allocation Standards

The design of urban roads must consider the adequate allocation of space for various road components, including lanes, sidewalks, shoulders, and medians. Space standards for urban roads ensure that all users, including pedestrians, cyclists, public transport, and private vehicles, can use the road safely and efficiently. The Space Standards in Urban Road in these studies are summarised in Table 2.1

### i. Right of Way (ROW)

The Right of Way (ROW) refers to the total width of land allocated for the construction of the road, including lanes, sidewalks, shoulders, and other infrastructure. ROW dimensions depend on the road's classification, expected traffic volume, and future expansion needs.

**Table 2.1: Space Standards in Urban Road**

| Sl. No | Type of Urban Road/Street | Land Width (m) and Type of Terrain | | |
|---|---|---|---|---|
| | | Plain | Rolling | Hilly |
| 1 | Arterial Road | 45-60 | 35-50 | 25-40 |
| 2 | Sub Arterial Road | 30-45 | 25-35 | 20-30 |
| 3 | Collector Street | 15-30 | 12-25 | 12-20 |
| 4 | Local Street | 10-15 | 10-15 | 10-15 |
| 5 | Urban Expressways | 45-60 | 35-50 | 30-40 |

The classification of terrain is often determined based on the percentage of cross slope or the rise and fall of the land, as specified in relevant IRC guidelines. According to IRC 73, terrains are categorized by cross slope as follows:

- Plain terrain: Cross slope less than 10%
- Rolling terrain: Cross slope between 10% and 25%
- Hilly terrain: Cross slope greater than 25%
- Additionally, as per IRC SP 30, the classification can also depend on the rise and fall of the terrain:
- Plain terrain: Rise and fall less than 15 meters
- Rolling terrain: Rise and fall between 15 and 30 meters
- Hilly terrain: Rise and fall greater than 30 meters
- These classifications are essential for determining the appropriate design and construction standards for infrastructure in different terrains.

**ii. Lane Widths**

Lane width is a critical design parameter because it directly influences road capacity and safety. The lane width determines the number of vehicles that can travel along a road at any given time and affects the ability of vehicles to manoeuvre safely: The minimum lane width for arterial and Sub arterial roads is 3.5 meters. These roads may include multiple lanes in each direction to

accommodate high traffic volumes. The lane width for collector roads is typically 3 meters, balancing traffic flow and providing space for pedestrians and cyclists.

**iii. Shoulders and Drainage**

Shoulders provide emergency parking space and accommodate pedestrians, cyclists, and other non-motorized vehicles. Proper drainage design is essential for preventing water accumulation and road damage. Shoulders on arterial roads should be at least 1.5 meters wide, while shoulders on local roads can be narrower, around 1 meter.

**iv. Drainage:**

Effective drainage systems, such as stormwater drains or culverts, must be incorporated into road design to manage rainfall runoff and prevent flooding. Drainage should be designed to handle localized rainfall and prevent erosion.

## 2.4 Cross-Section Design

The road cross-section determines how space is allocated to different elements such as lanes, shoulders, sidewalks, medians, and parking areas. The IRC provides specific guidelines for the cross-section of urban roads depending on their classification.

### 2.4.1 Urban Expressway

The cross-section of arterial roads is designed to accommodate high traffic volumes and a variety of vehicles. These roads typically have multiple lanes in each direction, dedicated bus lanes, wide shoulders, and landscaped medians to separate traffic and provide a green buffer shown in Figure 2.1.

- **Lanes**: The cross-section includes 3 to 5 lanes in each direction, with each lane measuring 3.5 m in width.
- **Shoulders**: Shoulders should be at least 1.5 m wide to accommodate non-motorized users and emergency vehicles.
- **Pedestrian Facilities**: Sidewalks should be at least 2 m wide, with pedestrian overpasses or underpasses provided at major intersections.
- **Median**: A central median of 2 to 4 m is included to separate opposing traffic flows and allow space for landscaping or public transport facilities.

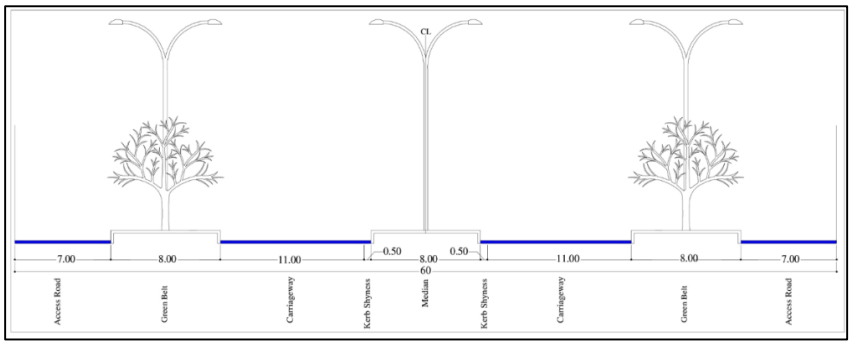


**Figure 2.1 Typical Cross Section-Urban Expressway**

### 2.4.2 Arterial Roads Cross-Section

The cross-section of arterial roads is designed to accommodate high traffic volumes and a variety of vehicles. These roads typically have multiple lanes in each direction, dedicated bus lanes, wide shoulders, and landscaped medians to separate traffic and provide a green buffer shown in Figure 2.2.

- **Lanes**: The cross-section includes 3 to 5 lanes in each direction, with each lane measuring 3.5 m in width.
- **Shoulders**: Shoulders should be at least 1.5 m wide to accommodate non-motorized users and emergency vehicles.
- **Pedestrian Facilities**: Sidewalks should be at least 2 m wide, with pedestrian overpasses or underpasses provided at major intersections.
- **Median**: A central median of 2 to 4 m is included to separate opposing traffic flows and allow space for landscaping or public transport facilities.

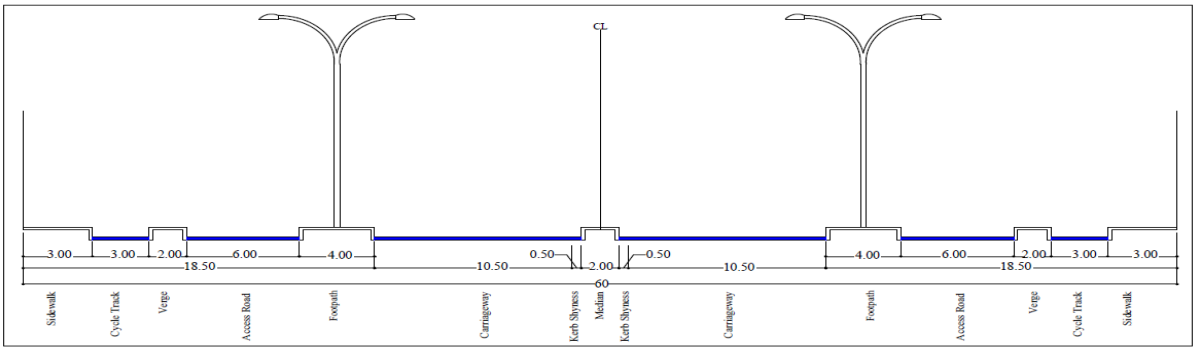


**Figure 2.2 Typical Cross Section-Arterial Road**

### 2.4.3 Sub-Arterial Roads Cross-Section

The cross-section of arterial roads is designed to accommodate high traffic volumes and a variety of vehicles. These roads typically have multiple lanes in each direction, dedicated bus lanes, wide shoulders, and landscaped medians to separate traffic and provide a green buffer shown in Figure 2.3.

- **Lanes**: The cross-section includes 3 to 5 lanes in each direction, with each lane measuring 3.5 m in width.
- **Shoulders**: Shoulders should be at least 1.5 m wide to accommodate non-motorized users and emergency vehicles.
- **Pedestrian Facilities**: Sidewalks should be at least 2 m wide, with pedestrian overpasses or underpasses provided at major intersections.
- **Median**: A central median of 2 to 4 m is included to separate opposing traffic flows and allow space for landscaping or public transport facilities.

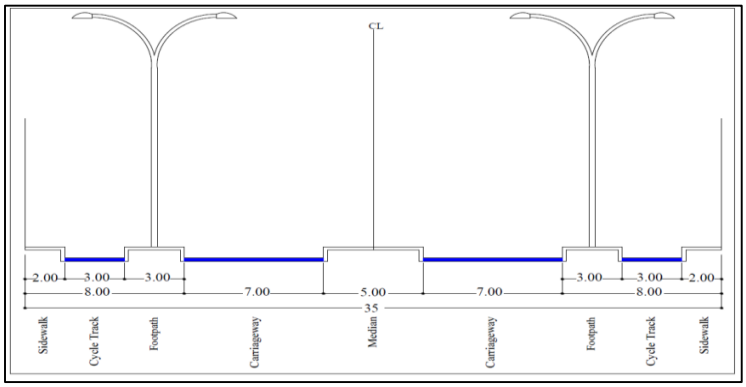


**Figure 2.3Typical Cross Section-Sub Arterial Road**

### 2.4.4 Collector Roads Cross-Section

Collector roads are designed to distribute traffic from arterial roads to local roads. Their cross-section balances traffic flow with the need for pedestrian and cyclist safety shown in Figure 2.4.

- **Lanes**: The cross-section includes 2 to 3 lanes in each direction, each 3 meters wide.
- **Shoulders**: Shoulders of 1 meter should be included to provide space for emergency stops and cyclists.
- **Pedestrian Facilities**: Sidewalks should be at least 1.5 m wide, with pedestrian crossings and traffic signals.
- **Median**: Medians are typically narrower on collector roads, ranging from 1 to 2 m, depending on available space.

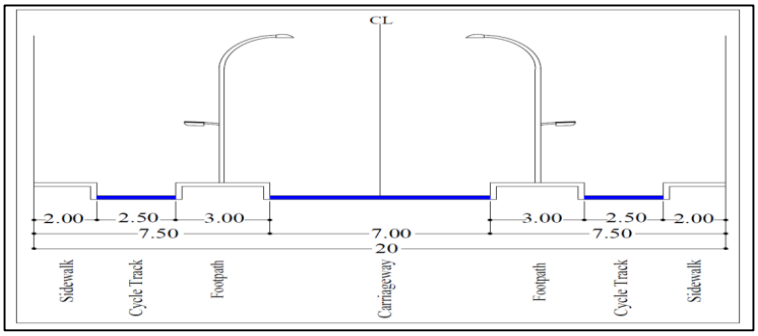


**Figure 2.4 Typical Cross Section-Collector Street**

### 2.4.5 Local Roads Cross-Section

Local roads prioritize pedestrian and cyclist safety. Their cross-section is designed to minimize traffic speed and provide safe passage for all road users shown in Figure 2.5.

- **Lanes**: Local roads generally have 1 lane in each direction, with each lane being 3 meters wide.
- **Shoulders**: Shoulders should be 1 meter wide to accommodate bicycles and provide space for pedestrians.
- **Pedestrian Facilities**: Sidewalks should be 1.5 m wide, and on-street parking should be provided where space allows.
- **Parking**: On-street parking is typically included in the design, with clear markings to ensure vehicles do not obstruct pedestrian movement.

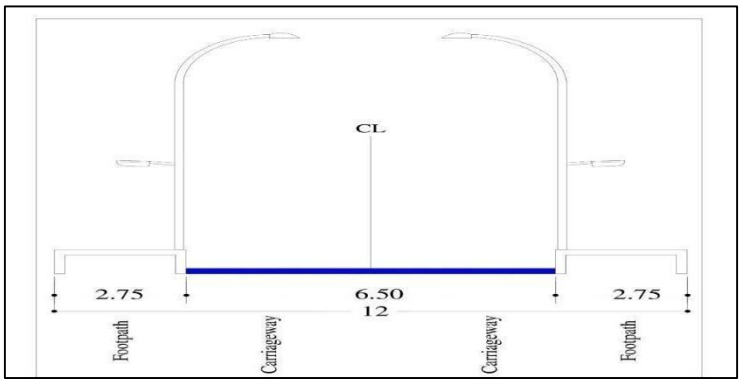


**Figure 2.5 Typical Cross Section-Local Street**

## 2.5 Safety Features

Ensure the implementation of safety features as per relevant IRC standards to enhance road safety and visibility. Install advance warning signs in compliance with IRC 67:2022, ensuring proper placement, visibility, and reflectivity to alert drivers of curves, speed control zones, and school zones. Place flexible median markers, object markers, and delineators in line with IRC 79, particularly at sharp curves and intersections, to provide clear guidance and reduce accidents.

Provide road markings as specified in IRC 35:2015, including lane lines, edge lines, stop lines, and pedestrian crossings, to ensure organized traffic movement and pedestrian safety. Enhance night visibility by installing road studs at lane dividers and on curves. Construct speed humps and speed tables adhering to IRC 99:2018 specifications, maintaining a circular arc profile with a chord length and radius as prescribed to control speeds effectively. Ensure the rise of speed humps is standardized at 10 cm, as deviations can lead to higher speeds or potential vehicle damage.

# Chapter 3 RECOMMENDATIONS FOR MITIGATION OF ROAD DUST WITHIN THE ROW THROUGH GREENING MEASURES

## 3.1 Introduction

Presence of vegetation plays an important role in dust mitigation by dual action of arresting the air-borne dust and preventing re-suspension of dust from unpaved areas. In Delhi's semi-arid bordering on humid sub-tropical climate, they also contribute to enhancing soil moisture and maintaining a favourable micro-climate. Thus, vegetation along roadside is significant not only for mitigation of road dust but also for various other co-benefits such as reduction of urban heat island, maintaining thermal comfort for pedestrians and groundwater recharge.

The major issues that were identified based on ground observation and after consultation with various stakeholders were mainly related to the nature of spaces with vegetation within the RoW and the vegetation itself. Some of the issues arising out of the nature of spaces include median design allowing for pedestrian footfall leading to mortality of plants, incomplete coverage of the soil with vegetation in the median and footpath leading to soil being blown on to the roads, space around the trees being usually bare and devoid of any vegetation on footpaths, space under flyovers meant for growing plants, often having C&D waste or encroachment, traffic islands and rotaries, unless paved, having bare vegetation along with the practice of pigeon feeding at many places, adding to dust in the area. Certain practices such as the current irrigation method through a thick hose employed for the roadside vegetation leads to spilling of loose soil onto the road. This dried soil adds to road dust in that stretch. The poor quality of vegetation at various roadside stretches could also be a result of air pollution, wrong choice of species, inadequate irrigation and poor maintenance.

It has been observed that many roads in Delhi NCR do not conform to the Indian Roads Congress geometric design standards for ROW for different hierarchy of roads, thus the recommendations for greening have been framed considering the possible width and section of median and footpath that may exist on the ground. Recommendations for greening of traffic islands and spaces under the flyover have also been given in the present section. In addition, species have been recommended on the basis of a combination of criteria such as their Air Pollution Tolerance Index (APTI), resilience to extreme weather conditions, native, deep rooted etc. Plant species with wide canopy, large and rough leaf surface area with perforated veins

have also been found to be more suitable for arresting dust. These criteria have been extracted from various documents such as Ministry of Housing and Urban affairs (MoHUA) Urban Greening guidelines (2014), Guidelines for developing greenbelts (2000) by Central Pollution Control Board (CPCB), Indian Roads Congress Manual of Planting and Landscaping of Urban Roads (2018), Street Design Guidelines by UTTIPEC (2009) etc.

Introduction

## 3.2 Recommendations for the Greening of Medians

### 3.2.1 Recommendations based on median width

Width of the median on different roads may vary from 0.5 m to more than 4 m, wherever median is present. Though, the prescribed minimum width of median is 1.2 m as per IRC:86 2018, medians of narrower width are also seen. It is possible that the median may have been modified depending on the available RoW, minimum required carriageway, traffic volume etc. In table 3.1, the first category of median width has been taken as a range less than prescribed median width as per IRC:86 2018.

**Table 3.1: Recommendations for greening of medians**

| S. No | Median width (m) | Paved/Plantation | Plantation Pattern and Species | Suggestions for maintenance of greenery |
|---|---|---|---|---|
| 1 | 0.5 – 1.2 | Permeable Paving | Seeded grass/gravel fill | - |
| 2 | 1.3 – 3 | Plantation | Single/double/triple row of shrubs (depending on the species) with native tall grasses along the edge of the median. Shrubs should not be more than 1.5 m height (IRC:SP:119-2018).<br><br>Shrubs: Bougainvillea, Thevetia nerifolia, Nerium oleander etc.<br><br>Grass: Dhoob, Vetiver etc. | Drip irrigation with treated water from STP wherever possible, use of treated waste water from Metro stations in the medians in the surrounding areas |
| 3 | 3.1 – 4 | Plantation | Medium trees interspersed with 4-6 rows of shrubs and | Drip irrigation with treated water from STP wherever possible, use |

| | | | | |
|---|---|---|---|---|
| | | | grasses OR 4-6 rows of shrubs depending on the species, with grasses along the edge. Shrubs should be pruned to 1.5 m height. Clear sight distance should be ensured by regular pruning of branches up to 4.5 m clear height above finished road level (IRC:SP:119-2018).<br><br>Trees: Plumeria obtusa (Frangipani)<br><br>Shrubs: Bouganvillea, Thevetia nerifolia, Nerium oleander etc.<br><br>Grasses: Dhoob, Vetiver<br><br>Trees should be planted at 10-15 m from each other (DUAC, 2020) | of treated waste water from Metro stations in the medians in the surrounding areas.<br><br>Scientific pruning of trees |
| 4 | More than 4.1 | Plantation or bioswales/infiltration trench | Trees interspersed with shrubs and grasses. Azadirachta indica (Neem), Alstonia scholaris, Terminalia arjuna, Dalbergia sisoo (Sheesham), Pongamia pinnata (Karanj) etc. Clear sight distance should be ensured by regular pruning of branches up to 4.5 m clear height above finished road level(IRC:SP:119-2018).<br><br>Trees should be planted at 10-15 m from each other (DUAC, 2020)<br><br>Species for Bioswales/infiltration trench:<br>Canna indica, Typha, Phragmites, Vetiver | Irrigation with treated wastewater.<br><br>Scientific pruning of trees<br><br>Preferred in areas prone to waterlogging/urban flooding. Gap to be left in the kerb for allowing stormwater inflow into the bioswale/infiltration |

| | | | | |
|---|---|---|---|---|
| | | | grass etc. | trench during rains |

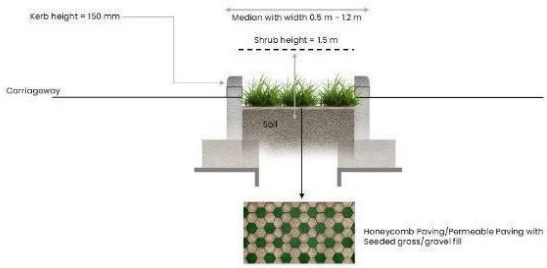


**Figure 3.1 Median Width: 0-5 m – 1.2 m**

Cross sectional View (Proposed)

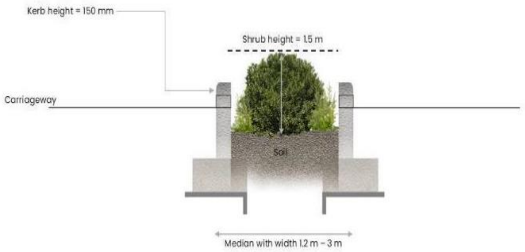


**Figure 3.2 Median Width 1.2 m – 3 m**

Cross sectional View (Proposed)

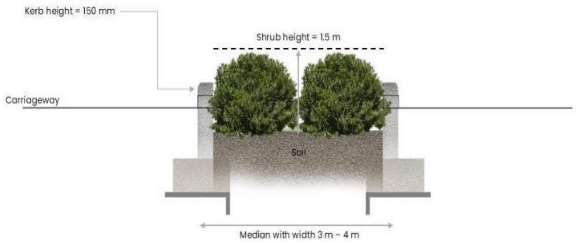


**Figure 3.3 Median Width : 3 m – 4 m (Option 1)**

Cross sectional View (Proposed)

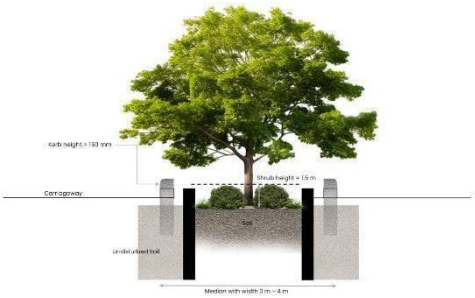

**Figure 3.4 Median Width: 3 m – 4 m (Option 2)**

Cross sectional View (Proposed)

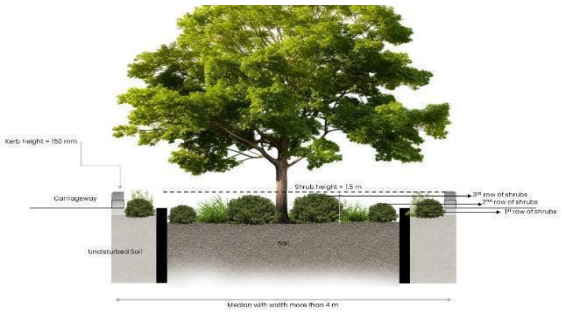


**Figure 3.5 Median Width : More than 4 m**

Cross sectional View (Proposed)

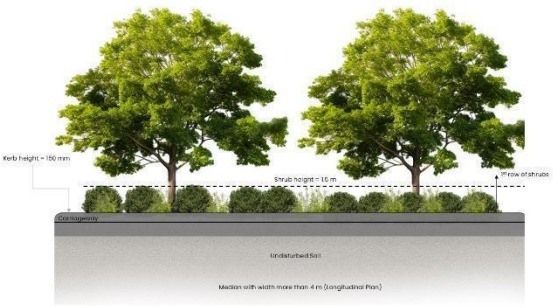


**Figure 3.6 Median Width : More than 4 m**

Longitudinal plan (Proposed)

Source: Adapted from IRC:SP:119-2018. Illustrations by SPA, Delhi

### 3.2.2 General Recommendations

- A gap of 8-12 inches to be left between the soil layer and the top of the kerbstone. Since IRC:86 2018 recommends 150 mm or 6 inches of kerb height for the median from the blacktop level for safety reasons, the top of the soil layer within the median may be lower and this should be integrated during planning and construction.
- The cross sectional and longitudinal slope of the carriageway needs to be studied before selecting the median stretch for infiltration trench or bioswale. Wherever, slope is towards the median, integration of median with infiltration trench/bioswale may be undertaken. Kerb cuts at appropriate places in the median will have to be introduced for stormwater to flow into the infiltration trench from the carriageway. It is critical to have the appropriate vegetation species for treating the stormwater before infiltration as stormwater runoff from carriageway may contain oil and grease.
- Use of cow dung slurry in the medians with plantations, at least once a year, preferably in the month of October/March to improve organic content of the soil and maintain soil moisture.
- To maintain a layer of mulch on unpaved surfaces wherever growing grasses and shrubs is not possible, for conserving soil moisture.
- The drip irrigation system may consist of a tank kept at the end of the median that could be filled at regular intervals with treated wastewater brought by tankers and the pipes with emitters that carry water to the plants from the tank. Other efficient options can also be explored for arranging for water for the purpose of drip irrigation. Water requirements for drought resistant plants like Bougainvillea would be less and they can be watered through the drip irrigation system accordingly.
- It is very important that the quality of treated wastewater being used for irrigation of roadside vegetation is within the permissible limit as per Central Pollution Control Board (CPCB) norms, otherwise it will lead to contamination of soil.
- Ensuring that the median is free of solid waste and construction and demolition (C&D) waste as C&D waste inhibits growth of healthy vegetation. Removal of all solid waste and C&D waste from the median by the agency responsible, at least once a month should be mandatory.

## 3.3 Recommendations for incorporating greenery in footpaths

### 3.3.1 Recommendations based on footpath width and pedestrian traffic

Footpath has been divided into three zones, dead or frontage zone, pedestrian zone and a multi-functional zone (IRC:103). As per IRC 103, an uninterrupted walking zone of minimum 1.8 m (width) and 2.2 m (height) should be provided. No tree branches, trees, utility poles, electric/ water/telecom boxes or signage should be placed within the clear height and width of the pedestrian zone. However, subject to this minimum, the width of the zone, varying from 1.8 m to 4 m, shall be based on the design flows and levels of service as mentioned in the guideline (Table 3.2). The plantation zone shall be provided over and above the prescribed width of the pedestrian zone as per the design flow.

**Table 3.2: Capacity of Pedestrian Zone (In Footpath)**

| S. No | Width of Pedestrian Zone (m) | Design Flow in Number of Persons per Hour | | | |
|---|---|---|---|---|---|
| | | In Both Directions | | All in One Direction | |
| | | LOS B | LOS C | LOS B | LOS C |
| 1 | 1.8 | 1350 | 1890 | 2025 | 2835 |
| 2 | 2.0 | 1800 | 2520 | 2700 | 3780 |
| 3 | 2.5 | 2250 | 3150 | 3375 | 4725 |
| 4 | 3.0 | 2700 | 3780 | 4050 | 5670 |
| 5 | 3.5 | 3150 | 4410 | 4725 | 6615 |
| 6 | 4.0 | 3600 | 5040 | 5400 | 7560 |

Source: IRC 86-2018

Space for plantation has been provided in the multi-functional zone of minimum width of 1.8 m so that it can accommodate a tree pit (IRC: SP:119-2018).

**Table 3.3: Recommendations for greening of footpath**

| **S. No.** | **Footpath width (m)** | | **Plantation Pattern and Species** | **Suggestions for maintenance of greenery** | **Remarks** |
|---|---|---|---|---|---|
| | Pedestrian Zone | Multi-functional Zone | | | |

| | | | | | |
|---|---|---|---|---|---|
| 1 | 1.8 (Minimum recommended width as per IRC:86 2018) | Not available | - | - | 1.8 m is the minimum pedestrian zone recommended by IRC:86 2018 |
| 2 | As per context | 1.8 | Tree spacing – 10 -15 m (DUAC, 2020) Azadirachta indica, Alstonia scholaris, Mangifera indica, Terminalia arjuna<br><br>Native grasses in tree pits around the tree trunk | Tree guards for protection of trees in the growing stage.<br><br>Honeycomb paver | Preferable for retail streets. It allows more flexibility and space for pedestrian movement. |
| 3 | As per context | 1.8 | Trees interspersed with continuous plantation strip<br><br>Plantation strip can also be developed as an infiltration trench. | Drip irrigation using treated wastewater, wherever possible | Suitable for roads with high-speed traffic to restrict pedestrians to the pedestrian zone (DUAC, 2020, UTTIPEC) |


**Figure 3.7: Zones in a footpath**

Source: Adapted from IRC: 103. Illustration by SPA, Delhi

### 3.3.2 General Recommendations

- To avoid choking root systems, and compaction, minimum tree opening size of 1.8 m x 1.8 m to be maintained. This may be covered by tree grates, porous pavers or planting.
- Preference for high - canopy / high branching trees with shrubs/ groundcovers as per requirement
- Ensuring visibility of safety and surveillance by regular pruning of shrubs/growing/ grown trees to maintain a clear walking zone.
- Do not plant large shrubs near signages; trees need to be pruned to keep signages and lighting clear.
- Plantation must occur outside of required sight lines as per IRC: SP:66.
- Planting should not block sight lines from roadside and active uses along the edges.
- Tree plantation should not be carried out in the following areas: (i) Within 5 m of a median cut, kerb cuts/entries and grade separators. ii) Within 25 m of a major traffic intersection having at least one arterial road.
- To prevent damage to carriageway, sub-grades and other utilities from long-rooted plants, sub-grade protection measures should be undertaken.
- Tree planting plan and lighting plan must be prepared together so that tree canopy do not obstruct lighting for the footpath users (UTTIPEC, 2009).
- IRC: SP:119-2018 guidelines may be referred for the details related to plantation.

## 3.4 Traffic Island and Central Island of the Roundabout/Rotary

As per IRC:65 2017, Inscribed Circle Diameter (ICD) for single lane is 28-40 m and double lane is 40-70 m while rotaries have an ICD of more than 70 m. Both rotaries and roundabouts can be designed as rain gardens that will allow surface runoff from surrounding roads and within the rotary to be infiltrated and recharge ground water. The roundabout or the rotary should be a depression for effective collection of surface runoff. This will help in increasing soil moisture as well. Gravel filter or vegetated filter (IRC: SP:119-2018) may be used along the boundary of the rotary or the inlet of surface runoff from the road. Fountains may be added in roundabout/rotary for enhancing wet deposition.

## 3.5 Under Flyover

A clear demarcation between paved and unpaved areas should be done through design. The paved area should be swept regularly and be free of solid waste and C&D waste. For the unpaved area, a combination of shade tolerant species of shrub and native grasses may be grown under the flyover and climbers may be used for pillars and walls of the flyovers. Few suggested species are Vernonia grandiflora, Ficus scandens, Bignonia unguiculata, Thunbergia grandiflora, Thunbergia mysorensis, Ipomoea purpurea, Ipomoea coccinea, Ipomoea cairica etc.

## 3.6 Edge/Boundary of the RoW

It should be mandatory for Government establishments to grow trees inside their boundary wall such that part of the tree canopy is in the RoW. In case space is not available inside the plot, creepers/climbers along the boundary walls can be grown. This will introduce vertical greens within the RoW which do not have space for plantations.

## 3.7 Prioritisation of Road Stretches for Greening

Road stretches for greening may be prioritised based on the following criteria:

i) Road dust levels (could be observation based if air quality monitoring data is not available)

ii) Road stretches with unpaved medians and underutilised plantation zones in footpaths

iii) Areas experiencing waterlogging during rains may be taken up first for bioswales/infiltration trenches

iv) Areas with high or sensitive exposed population to road dust (areas with high pedestrian traffic, areas with hospitals and schools),

# Chapter 4 CONTROLLING ROAD DUST THROUGH IMPROVED ROAD MAINTENANCE PRACTICES TO ENHANCE AIR QUALITY

## 4.1 Introduction

The rapid deterioration of air quality in Delhi and neighbouring cities is closely linked to the high levels of particulate matter ($PM_{10}$ and $PM_{2.5}$). Road dust, a major source of these pollutants, arises from poorly maintained roads and inadequate dust suppression measures. Recognizing this issue, the a roadmap for controlling road dust by enhancing road maintenance practices, guided by national standards and expert advice is proposed. The status of the main road network (approx. 18600 kms as on 31st March 2023) is summarised in Table 4.1 below.

**Table 4.1: Status of Road Network in Delhi-Agency-Wise (As on 31st March 2023)**

| S. No. | Agency | Road length (km) |
|---|---|---|
| **1.** | Municipal Corporation of Delhi | 12703.95 |
| **2.** | New Delhi Municipal Council | 1290 |
| **3.** | DSIIDC | 2428 |
| **4.** | I&FC | 357.39 |
| **5.** | DDA | 435* |
| | Public Works Department | |
| **a.** | National Highways | 35 |
| **b.** | Other Roads | 1345 |

**Source: Delhi Statistical Handbook 2023**
***As on 31st March 2019**

**The assessments revealed the following:**

- Cracks, potholes, and rutting lead to loose dust particles that become airborne due to vehicular traffic.
- Local roads and secondary streets are often neglected in regular maintenance schedules.
- Maintenance is often carried out after significant road damage, leading to prolonged dust emissions.
- Lack of a standardized, proactive system for assessing road health exacerbates the problem.
- There is a critical need to shift away from manual maintenance processes to a rational, modern asset management strategy that ensures efficiency and long-term sustainability.

- Maintenance practices do not consistently follow IRC guidelines on road asset management and maintenance of bitumen, cement concrete roads, resulting in inefficient planning and execution.

To address these challenges, a comprehensive strategy is recommended:

**A. Adoption of a Standardized Road Asset Management System (RAMS) for all roads**

**A Web-GIS-based Road Asset Management System (RAMS) must be developed, adhering to guidelines specified in IRC 130-2020, which provides standards for road asset management.**

**Key Features of RAMS:**

- **RAMS software:** Web-GIS based System of the Delhi road network, Right-of Way (RoW) details, pavement functional and structural health data including traffic and axle load intensity and maintenance history.
- **Adoption of Modern Survey Tools for Data Collection:** Regular assessment of functional and structural conditions of roads as per the guideline and frequency given in IRC 130-2020.
- **Analysis to develop Annual Maintenance Plan:** Use of AI based tools/management tools like HDM4 to develop timely maintenance strategies.
- **Prioritization Framework:** Prioritize maintenance, based on severely distressed roads having heavy traffic and high dust emission potential.

Figure 4.1 below illustrates the components and workflows of the proposed RAMS, integrating condition monitoring and predictive analysis for improved road maintenance

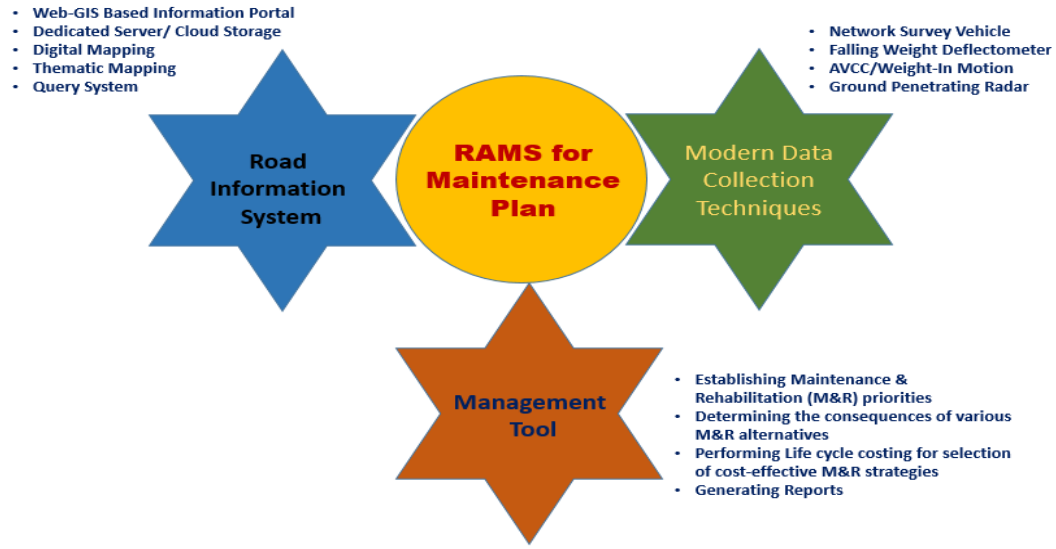


**Figure 4.1 Components and workflows of the proposed RAMS**

**B. Prioritisation of maintenance activities using Pavement Condition Index (PCI) for collector, local streets and other low volume roads.**

The **Pavement Condition Index (PCI)** concept from IRC 82-2023 should be adopted to evaluate road quality and plan maintenance activities:

- Assessment of road based on six most dominating pavement surface parameters/conditions e.g. riding quality, pothole, rutting, cracking, ravelling and patchwork.
- Assessment Scale: Roads will be rated on a PCI scale of 0-100:

Figure 4.2 above illustrates the six most dominating pavement surface related parameters used to calculate the PCI Score and ratings from excellent condition to Failed condition.

Maintenance recommendations from routine maintenance to reconstructions based on PCI scores are given in Table 4.2.

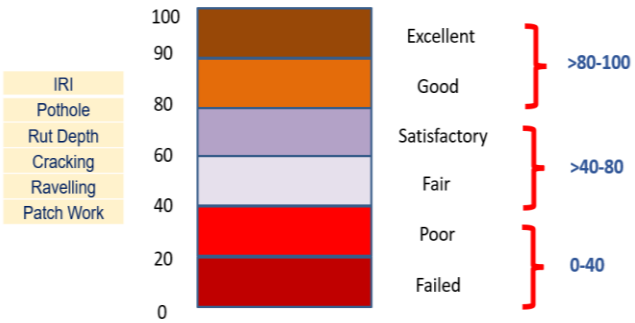


**Figure 4.2 Road Parameters, PCI Score and Condition Ratings**

**Figure 4.3: Maintenance Recommendations based on PCI**

| PCI Score | Suggested Maintenance |
|---|---|
| **91-100** | Excellent (routine maintenance, crack sealing, pothole repair etc.). |
| **81-90** | Good (preventive maintenance like micro surfacing). |
| **61-80** | Satisfactory (periodic maintenance, thin overlay as per sec 9.5 of IRC 82-2023 document). |
| **41-60** | Fair (minor rehabilitation based on structural evaluation) based on Structural Evaluation using FWD |
| **21-40** | Poor (major rehabilitation based on structural evaluation) based on Structural Evaluation using FWD |
| **0-20** | Fail (Re-construction) based on redesigning |
| **Note:** | Drainage and roadside dust cleaning are must in all conditions |

**C. Adoption of Modern Survey Technologies**

To ensure accurate assessment and targeted interventions, the following technologies are recommended:

- Network Survey Vehicle (NSV): Automated inspection for GPS tagged data in respect of road inventory, right-of-way video, riding quality, pavement surface distresses (pothole, cracks, ravelling, edge brake etc.), geometry etc. For smaller road length where NSV system cannot be deployed, GPS & AI integrated videography survey based systems can be used.
- Falling Weight Deflectometer (FWD): Evaluation of pavement strength for structural health monitoring.
- Ground Penetrating Radar (GPR): Non-invasive subsurface analysis.
- Portable-Weigh-In-Motion System (WIM): Axle Load Monitoring
    - (Static weigh Pads in case portable WIM is not available)
- Automatic Vehicle Counter Cum Classifier (AVCC): Traffic Volume Count

**D. Compliance with IRC Standards:**

- Surveys and assessments should align with the methodologies outlined in IRC 130-2020, IRC 82-2023, IRC SP 83-2018 and other relevant IRC guidelines.

**E. Advisory Services**

- Engage technical consultants having sufficient expertise in implementation of RAMS.

**F. What Not to Do in Road Maintenance to Control Dust and Air Pollution**

- Avoid Deferred Maintenance: Postponing repairs for cracks, potholes, and rutting allows loose dust particles to become airborne, worsening air quality. Ensure timely and proactive interventions using advanced RAMS.

- Do Not Use Manual Methods: Use modern, standardized techniques for accurate and efficient data collection and maintenance techniques.

- Avoid Open Storage of Loose Materials: Storing construction materials like sand, gravel, or asphalt uncovered near roads contributes to dust dispersion. Always cover and secure materials.

- Do Not Ignore Low-Traffic Roads: Neglecting maintenance of street or local roads can lead to unchecked dust emissions. Maintain consistent care for all road types.

- Minimize Uncoordinated Excavations: Random and poorly planned digging or utility work on roads results in dust dispersion. Properly coordinate such activities and restore the road surface promptly after work.

**G. Road Maintenance Recommendations**

**i. Develop a Standardized Road Asset Management System (RAMS):**

- Identify one nodal agency among all road agencies (PWD/MCD etc.) and Implement a Web-GIS-based RAMS for the entire road network of approx. 18600 kms+, including Right-of-Way (RoW) details, pavement health, traffic loads, and maintenance history, adhering to IRC 130-2020 guidelines.

- The existing base map from previous studies, may be used after updating the spatial (addition of roads) and attribute data (road condition, traffic, axle load, pavement crust etc.) for the development of Delhi RAMS.

- Use Modern Survey Technologies for RAMS Data.

    - Network Survey Vehicle (NSV): Conduct GPS-tagged automated inspections for road inventory, right-of-way video, and pavement surface conditions (cracks, potholes etc.). Use GPS and AI-integrated videography based systems for shorter roads unsuitable for NSV deployment.
    - Falling Weight Deflectometer (FWD): Conduct FWD survey to decide the structural overlay.
    - Ground Penetrating Radar (GPR): Use GPR for non-destructive subsurface investigations.
    - Portable Weigh-In-Motion System (WIM): Monitor axle loads; use static weigh pads if WIM is unavailable.
    - Automatic Vehicle Counter cum Classifier (AVCC): Monitor traffic volume and axle loads.

- Utilize the RAMS data to calculate the Pavement Condition Index (PCI) as per IRC 82-2023 to prioritize the maintenance activities.

- Utilize the RAMS data with standard maintenance management tool to develop annual maintenance plan/best maintenance strategy based on life cycle cost analysis.

**ii. Maintenance Decisions B based on IRC Standards:**

- Conduct surveys and execute maintenance activities in accordance with IRC 130-2020, IRC 82-2023 (for bituminous roads), and IRC SP 83-2018 (for cement concrete roads) standards.

**iii. Engage Expert Advisory Services:**

- Engage technical consultants to support the implementation of RAMS and PCI-based maintenance prioritization effectively.

iv. **Form a dedicated task force for interdepartmental coordination among all road agencies and conduct regular compliance audits to ensure adherence to guidelines.**
v. **Build capacity within agency on road maintenance through training workshops.**
vi. **Launch public awareness campaigns to encourage citizen participation in reporting road damage.**

# Chapter 5 NEW TECHNOLOGIES FOR ROAD CONSTRUCTION AND MAINTENANCE FOR DUST CONTROL

## 5.1 Use of Cold Mix Technology

Hot mixed laying techniques using hot and melted bitumen as binder are used at large scale in construction and maintenance of bituminous roads, though it causes emission of greenhouse gases. Bitumen is heated to 160–170 °C and aggregates are heated to 150-160 °C consuming enormous amount of energy. Cold Mix technology has been developed for the construction of bituminous surfacing of low volume roads which are better not only from economic point of view but are also eco-friendly using bitumen emulsion. Cold mix technology is a designed tailor made bitumen emulsion with certain performance additives like long carbon chain fatty acid or amine showing medium and slow characteristics. Mix can be prepared at ambient temperature. With the support of Indian Roads Congress specification "Use of Cold Mix Technology in Construction and Maintenance of Roads Using Bitumen Emulsion (IRC:SP 100)" has also been published in 2015.

- **Cold Mix Technology for Overlaying:**

Cold mix technology should be adopted for overlaying to minimize dust generation and reduce emissions during maintenance. This technology, compliant with IRC SP 100, offers an environmentally friendly alternative to hot mix practices and ensures better workability under varying traffic conditions (Figure 5.1).

- **Mechanized Onsite Cold Mixing and Laying**

Machines equipped for onsite mixing and laying of cold bituminous mixes should be employed instead of manual methods or open concrete mixers. This approach ensures consistent quality, reduces material wastage, and minimizes dust and emissions during the mixing process, promoting cleaner and more efficient road repairs and construction.

- **Micro-Surfacing for Structurally Sound Pavements:**

Micro-surfacing should be used on structurally sound pavements as an alternative to conventional hot mix resurfacing. This method reduces dust, enables the application of thinner layers, and enhances cost and resource efficiency while maintaining the pavement's structural integrity.

- **Bitumen Emulsion for Coating:**

All prime and tack coating operations should utilize bitumen emulsions in place of hot bitumen to reduce environmental impact.

## 5.2 Use of Mechanised Pothole Repair Solutions

- **Pothole Classification**:
  Potholes are classified based on their size into three categories (IRC 82):
  - Small: Depth of 25 mm and width of 200 mm.
  - Medium: Depth of 25 to 50 mm and width of 500 mm.
  - Large: Depth exceeding 50 mm and width of 500 mm.

  It is recommended that all potholes be repaired promptly at the small or medium size to prevent further deterioration, reduce repair costs, and minimize dust generation.

- Mechanized solutions, including machines equipped for tack coating, onsite mix preparation, and compaction, should be employed using cold mix technology with 13mm NMAS and above stone aggregates and bituminous emulsion as per IRC SP 100 to ensure efficient and timely pothole repairs.

## 5.3 Replace Bitumen Mastic with Stone Mastic Asphalt (SMA)

Bitumen mastic, which is hard and impermeable wearing course, is commonly used at intersections, decks of flyover and rail over bridges (ROB) to provide adequate skid resistance. Bitumen mastic is an energy and dust intensive process during preparation at site and laying. Therefore, wearing course of Stone Mastic Asphalt (SMA) (as per IRC SP 79) is recommended as replacement of Bitumen Mastic which offers a sustainable alternative to conventional bitumen mastic SMA shows better durability, resistance to wear, and reduced susceptibility to moisture damage, making it ideal for urban roads subjected to heavy and slow moving traffic loading.

## 5.4 Cement Grouted Bituminous Mix (CGBM)

Deploy CGBM technology in urban road construction for its high resistance to moisture-induced damage, retained flexibility and durable wearing course as per IRC SP 125. It is particularly suitable for waterlogging-prone areas, as it provides enhanced durability and stability under

wet conditions, reducing the risk of pavement deterioration. CGBM technology helps in reducing the need for frequent maintenance and overlaying, as it enhances the durability and longevity of the pavement.

## 5.5 Inter-agency Coordination for Immediate Repairs

It is essential to establish strong inter-agency (DJB, BSES, MTNL, IT Dept & others) coordination for timely repair of roads. If any agency or contractor digs or damages the road, they should be mandated to repair it immediately. This ensures road integrity is maintained and prevents prolonged disruptions or deterioration of infrastructure.

## 5.6 General Recommendations during Construction and Maintenance of Roads

Road construction activities, particularly in the National Capital Region (NCR), contribute significantly to ambient dust and emissions, adversely impacting air quality. Sources include excavation, grading, transportation, mixing of materials, and paving.

- **During the Construction of Soil Subgrade Layers**
  During the construction of soil subgrade layers, frequent watering should be conducted to suppress dust generation. Soil stabilizers can be applied to create a partially bound layer, which helps in reducing dust. Additionally, covering material stockpiles will prevent dust from becoming airborne. Limiting vehicle speeds is also essential to reduce dust kick-up from construction vehicles, ensuring a cleaner environment during this phase.

- **During Construction of Granular Layers**
  In the construction of granular layers, similar methods can be employed to control dust. Regular watering should be practiced to maintain moisture levels and reduce dust. Soil stabilizers should be used to form a partially bound layer, which minimizes dust formation. Stockpiles of materials should also be covered to limit dust spread. Moreover, reducing vehicle speeds on the site will help in minimizing the dust generated by vehicles.

- **During Construction of Asphalt or Concrete Layers**
  For asphalt or concrete layer construction, installing baghouses in hot mix plants is crucial to capture and control dust emissions, reducing air pollution. Proper pavement

curing is necessary to ensure that the surface cures correctly, minimizing dust production during the initial phase. Additionally, scheduling paving activities during periods of low wind and humidity is important to control dust dispersion and ensure a cleaner working environment.

- **During Maintenance Phase of Pavement**

  In the maintenance phase of the pavement, applying surface sealants is an effective method to reduce dust emissions. Pavement sealing creates a protective layer that minimizes the release of dust particles. Additionally, planting grass or shrubs along the road edges helps to prevent erosion and reduce the spread of dust, contributing to a cleaner and more sustainable environment.

| Title of Treatment | Traffic (CVPD) | Climate | | Choice of Emulsion |
|---|---|---|---|---|
| | | Temperature | Rainfall | |
| Prime Coat | No Limit | No Limit | No Limit | SS-1 |
| Tack Coat | No Limit | No Limit | No Limit | RS-1 |
| Seal Coat | <1500 | No Limit | No Limit | SS-2 |
| Sand Seal | <1500 | No Limit | No Limit | SS-2 |
| Cap Seal | <3000 | No Limit | No Limit | RS-2 , SS-2 and Modified |
| Chip Seal | <1500 | Avoid in Cold Climate | No Limit | RS-2, Modified |
| Slurry Seal | <1500 | No Limit | No Limit | SS-2 |
| Microsurfacing | No Limit | No Limit | No Limit | Modified |
| OGPC | <1500 | Moderate & cold climate (maximum air temperature 40°C) | Medium | MS/SS-2 and Tailormade |
| MSS | <1500 | Moderate & cold climate (less than 40°C) | Low | MS/SS-2 and Tailormade |
| BM | <1500 | Moderate & cold climate (maximum air temperature 40°C) | Low | MS/SS-2/ Tailormade |
| SDBC | <3000 | Moderate & cold climate (maximum air temperature 40°C) | Low | SS-2/Tailormade |
| Half Warm Mix (DBM, SDBC, BC) | <4500 | Moderate & cold climate (maximum air temperature 40°C) | No limit | SS-2/Tailormade |
| Cold Recycling | No limit | Moderate and cold climate | No limit | SS-2/Tailormade |
| Patching | No Limit | No Limit | No limit | MS/SS-2/ Tailormade |

**Figure 5.1 Selection of cold mix layer as per traffic condition (IRC SP 100)**

# Chapter 6 RECOMMENDATIONS FOR A STANDARD FRAMEWORK

## 6.1 Approaches for Recommending Standard Framework

Urban space standards are essential for designing efficient, safe, and sustainable road infrastructure, in line with the Indian Roads Congress (IRC) guidelines. Proper Right-of-Way (RoW) allocation ensures sufficient space for carriageways, pedestrian pathways, cycling tracks, and utilities, while considering road hierarchy. This careful planning promotes smooth traffic flow, reduces congestion, and improves urban mobility leading towards reduction in generation of road dust.

Incorporating green infrastructure, including tree plantations and landscaped medians, enhances the environmental aspect of road design. Sustainable practices, such as using native, pollution-resistant plants and drip irrigation, reduce maintenance costs and provide ecological benefits. Roads in high-dust require specialized solutions like dust barriers, permeable pavements, and flood-resilient designs to address specific challenges.

Advanced maintenance strategies, including GIS-based asset management, Network Survey Vehicles (NSV), and Ground Penetrating Radar (GPR), help monitor road conditions and extend their lifespan. Adhering to IRC guidelines ensures uniformity in infrastructure development, balancing mobility, safety, sustainability, and resilience. This framework emphasizes using Cold Mix Technology, micro surfacing, and bitumen emulsion for effective road repairs and overlays, as outlined in IRC: SP 100 and SP 82. Mechanized pothole repair machines and SMA are recommended for heavy-traffic roads. Additionally, CGBM is advised for waterlogged urban roads, along with dust control and stabilization during construction. This holistic approach considers present and future demands, addressing challenges like congestion, pollution, and climate resilience while enhancing the overall quality of urban life. Recommendations presently made in this report are applicable to Delhi only; however they can subsequently be extended to other cities in the National Capital Region (NCR).

## 6.2 Recommendations for Urban Space Standards

**Do's: As per Indian Roads Congress Guidelines**

1. **Right-of-Way (RoW)**
    - Allocate ROW as per IRC guidelines according to road hierarchy to accommodate all functional elements like carriageways, footpaths, cycle tracks, medians, and utility corridors (IRC 86: 2018)

2. **Carriageway**
    - Design carriageways width and road markings as per IRC guidelines to ensure smooth traffic flow and prevent encroachment.
    - Design **6-**lane or 4-lane divided Carriageway for Arterial roads, 4-lane divided or 2-lane divided for Sub Arterial and 2-lane divided for Collector Streets. Strictly follow road hierarchy while connecting the roads.
    - Ensure a lane width of **3.5 meters** for arterial and Sub arterial roads and **3.0 meters** for local streets and access roads to residential areas with kerb. (IRC 86: 2018)
    - Ensure adequate slope and widening of Carriageway and lanes on Curves as per IRC guidelines
3. **Pedestrian Facilities**
    - Provide footpaths on both sides of the road with a minimum width of 1.8 meters, ensuring accessibility for pedestrians (IRC 103: 2023)
4. **Cycle Tracks**
    - Design cycle tracks with a smooth, skid-resistant surface and a minimum width of 2.5 meters for bi-directional use.
5. **Service Lanes and Parking:**
    - Allocate separate service lanes in commercial and mixed-use zones.
    - Provide designated parking lanes, bus-bays, loading-unloading bays, parking areas as per planned requirement and discourage on-street parking in main corridors.
6. **Central Median:**
    - Maintain a central median width of 1.2–2.0 meters with green cover and reflective crash barriers.
    - Roads with 4 or more traffic lanes shall have medians with the pedestrian refuge of a minimum 3 m waiting area (IRC:103)
    - The median should be of uniform width in a particular section. However, where changes are unavoidable, a transition of 1V in 15H (for every 1 unit of Vertical change, there is a 15-unit Horizontal distance). to 1V in 20H must be provided.

7. **Drainage:**
    - Ensure a proper drainage slope of **1–2%** for surface water runoff.
    - Ensure proper width of drains and connection with the sewer lines.
    - Integrate stormwater harvesting features like recharge pits and rain gardens.
8. **Safety Features:**
    - Provide signs as per IRC 67:2022, ensuring appropriate placement, visibility, and reflectivity standards.
    - Install advance warning signs at curves, speed control zones, and school zones to enhance safety.
    - Install flexible median markers, object markers, and delineators as per IRC 79, especially on sharp curves and near intersections.
    - Provide road markings as per IRC 35:2015, including lane lines, edge lines, stop lines, and pedestrian crossings.
    - Install road studs at lane dividers and on curves for enhanced night visibility.
    - Provide speed humps and speed tables as per IRC99:2018 specifications that speed humps are based on the shape of a circular arc with a radius and a chord length as per IRC guidelines to achieve the desired speed.
    - Provide rise of Speed humps 10 cm (rises less than assumed 10 cm will result in higher speeds and rises that higher than 10 cm may cause damage to vehicles).
9. **Street lights and utilities:**
    - Provide Street Lighting as per IRC guidelines
    - Provision for electricity cables, fibre optic cables and other public utility services.

**Don'ts: For Space Standards and Cross Sections**

1. **Encroachment and ROW Misuse:**
    - **Don't** allow commercial or informal encroachments on ROW, including footpaths and cycle tracks.
    - **Don't** compromise on the minimum width of functional elements to fit additional non-essential uses.
2. **Carriageway Design:**

- **Don't** create overly wide carriageways in local streets, which can encourage speeding.

3. **Pedestrian and Cycle Facilities:**
    - **Don't** ignore the need for continuous, obstruction-free footpaths and cycle tracks.
4. **Median and Landscaping:**
    - **Don't** leave medians without reflective delineators or crash barriers in high-speed corridors.
5. **Safety and Access:**

- **Don't** block access to footpaths or cycle tracks with poles, signage, or construction debris.
- **Don't** overlook safety features like guardrails and lighting in accident-prone zones.

## 6.3 Recommendations for Mitigation of Road Dust in ROW Through Greening Measures

**DO's**

**Plantation Plan:**

1. Prepare separate plantation plans for Footpaths, Median, Traffic Island, Roundabouts, and under the Flyover. The plantation plan should include a list of trees, shrubs, creepers, climbers, and grasses that may be grown in specific conditions. For example, big trees cannot be grown in small traffic islands or narrow medians. Shade-tolerant species have to be grown under the flyover etc.

2. While preparing the plantation plan, focus on native, drought-resilient species and species that are tolerant to pollution and are efficient at arresting dust. For example Azadirachta indica, Alstonia scholaris, Terminalia arjuna, Dalbergia sissoo (Sheesham), Pongamia pinnata (Karanj), Bougainvillea, Dhoob, Vetiver etc. (IRC SP: 119)

3. Plan for tree plantation to be in conjunction with the street lighting plan and other utility plans. Trees should not obstruct light and traffic signals.

**Design interventions:**

1. Include infiltration trenches/ bioswales, particularly in road stretches prone to waterlogging, wherever feasible. Road agency should identify medians and footpath stretches of more than 4 m width where infiltration trench/bioswales are feasible in the city and provide a plantation and maintenance plan. Studies for assessing the longitudinal and cross sectional slope of the carriageway to be undertaken to understand the direction of the water flow in the stretch. Introduce kerb cuts in medians/footpaths with infiltration trenches/bioswales for stormwater runoff to flow into the trench/bioswale without obstruction.
2. Increase the gap between the top of the kerb and top of the soil layer in the median, and plantation strips on footpaths to stop soil from blowing over during high wind episodes. There should be an 8-12 inches gap between the top of the kerb and top of the soil layer while maintaining the kerb height of 150 mm as per IRC guidelines. Road agency to undertake this for all new roads during design and construction. This to be retrofitted in the existing roads.
3. Encourage vertical gardens on boundary walls, flyover pillars by focusing on creepers and climbers. Keep a minimum of 0.5 m strip of unpaved area with good earth at the base of the pillars or flyover for planting climbers and creepers. For example, Vernonia grandiflora, Ficus scandens, Bignonia unguiculata, Thunbergia grandiflora, Thunbergia mysorensis may be grown. Road agency should identify road stretches in the city where a vertical garden is feasible and provide a plantation and maintenance plan.
4. Tree plantation should be restricted to the multi-functional zone as identified by IRC guidelines. This zone is over and above the minimum pedestrian zone requirement of 1.8 m.

**Sustainable practices:**

1. Conserve soil moisture in unpaved areas within the RoW. It could be done through mulching, use of cow dung slurry etc.
2. Plant saplings have to be protected from stray cattle and pedestrians till their roots become stronger. Tree guards of eco-friendly material like bamboo may be used for the same.
3. Identify stretches of medians in the city where drip irrigation is feasible. Introduce drip irrigation in medians to conserve water, wherever feasible. In medians, where it is not

possible to have drip irrigation, irrigation has to be done with a hose pipe of a diameter that does not spill soil into the carriageway.

4. Have an audit system for checking roadside vegetation by a third-party agency to ensure regular maintenance and health of the vegetation.
5. Protect trees during construction or utility maintenance activity.
6. Do scientific pruning of trees regularly to prevent their falling during storms and obstruct view of vehicles and pedestrians.
7. Refer to IRC:SP: 119-2018, Manual of planting and landscaping of urban roads for guidance over and above these instructions.

**DON'TS**

1. Don't plant trees within 5 m of a median cut, kerb cuts/entries and grade separators and within 25 m of a major traffic intersection having at least one arterial road.
2. Don't plant trees that are not native to the country like Eucalyptus, Australian Acacia, Lantana, Luceana, Mast tree (False Ashoka), Prosopis Juliflora. Do not plant grasses that require high maintenance.
3. Don't concretise around tree trunks. Tree pit should be a minimum of 1.8 m x 1.8 m for the roots to breathe and a minimum excavated depth of 1.2 m.
4. Don't leave any unpaved area within the RoW exposed.

Road stretches for greening may be prioritised based on the following criteria:

i) Road dust levels (could be observation based if air quality monitoring data is not available)

ii) Road stretches with unpaved medians and underutilised plantation zones in footpaths

iii) Areas experiencing waterlogging during rains may be taken up first for bioswales/infiltration trenches

iv) Areas with high or sensitive exposed population to road dust (areas with high pedestrian traffic, areas with hospitals and schools).

## 6.4 Recommendations for the Development of Delhi Road Assessment Management System

**Preparation and Planning**

- Nodal agency to oversee the implementation of Delhi RAMS for all road agencies.

- Nodal agency shall engage technical consultants with expertise in RAMS and PCI-based prioritization.
- Utilize the existing standard base map available with previous studies and update all spatial and attribute data in respect of all Delhi roads for development of Delhi RAMS.
- Procure/implement a Web-GIS-based Road Asset Management System/Software (by nodal agency) to create GIS database for Delhi Road Network in respect of Right-of-Way (RoW), pavement conditions (functional and structural), traffic loads, maintenance history etc as per IRC 130-2020 standard on road asset management.
- Align all maintenance practices with IRC standards (IRC 130-2020, IRC 82-2023, IRC SP 83-2018 or other relevant IRC standards).

**Data Collection Using Modern Survey Technologies**

- **Network Survey Vehicle (NSV):** Conduct GPS-tagged automated inspections for road inventory, riding quality, and pavement surface conditions (e.g., cracks, potholes, rutting).
- **Alternative Methods for Smaller Roads:** Use GPS and AI-integrated videography systems where NSV deployment is unsuitable, like for street roads.
- **Falling Weight Deflectometer (FWD):** Evaluate pavement strength for structural overlay design.
- **Ground Penetrating Radar (GPR):** Perform non-destructive subsurface analysis to collect pavement structure details.
- **Portable Weigh-In-Motion System (WIM):** Monitor axle loads; use static weigh pads if WIM is unavailable.
- **Automatic Vehicle Counter Cum Classifier (AVCC):** Collect traffic volume data.

**Road Condition Assessment and Maintenance Prioritization**

- Calculate Pavement Condition Index (PCI) for all roads as per IRC 82-2023 guidelines:
    - Use six primary parameters: riding quality, potholes, rutting, cracking, ravelling, and patchwork.
    - Classify roads based on PCI scores into categories from "Excellent" to "Failed" to determine maintenance needs.
        - Routine maintenance for roads rated "Excellent" (PCI 91-100).
        - Preventive measures for roads rated "Good" (PCI 81-90).

        - Periodic Maintenance for roads rated “Satisfactorily” (PCI 61-80)
        - Minor Rehabilitation for roads rated “Fair” (PCI 41-60) based on FWD data analysis
        - Major Rehabilitation for roads rated “Poor” (PCI 21-40) based on FWD data analysis
        - Reconstruction for “Failed” roads based on re-designing
- Ensure regular drainage cleaning and roadside dust removal as part of all maintenance activities.

**Development of Best Maintenance Strategies at Network Level**

- Utilize RAMS data to analyse road health and generate annual maintenance plans using standard road maintenance management tools based on life cycle cost analysis.

**Capacity Building**

Conduct training workshops to build capacity among road agency personnel on modern road maintenance practices.

**Monitoring and Coordination**

- Form a dedicated task force to facilitate interdepartmental coordination among road agencies.
- Conduct regular compliance audits to ensure adherence to IRC guidelines.

**Public Engagement and Transparency**

- Launch public awareness campaigns to:
    - Educate citizens on reporting road damage and dust-related issues.
    - Promote the use of eco-friendly construction practices to mitigate dust generation.
- Deploy a public web portal integrated with RAMS to enable citizen reporting and tracking of road maintenance issues.

**Prohibited Practices**

- Avoid deferred road maintenance of road damage such as cracks and potholes.

- Promptly restore road surfaces after utility works.
- Ensure proper storage and covering of loose construction materials to prevent dust dispersion.
- Prohibit the use of manual survey and maintenance methods.
- Ensure regular drainage cleaning and roadside dust removal

**Implementation Timeline for RAMS:** 12 to 15 months

## 6.5 Recommendations for Technological Interventions for Dust Control

**Do's: As per Indian Roads Congress Guidelines**

- **Use Cold Mix Technology as per** IRC: SP 100 for overlaying the surface using mechanized equipment for onsite cold mix preparation and laying.
- Use micro-surfacing as an overlay on structurally sound pavements as per IRC: SP 100.
- Replace hot bitumen with bitumen emulsion for prime and tack coating.
- All potholes should be repaired promptly at the small or medium size (IRC SP 82)
- Use mechanized pothole repair machine using cold mix technology with 13mm NMAS aggregates as per IRC SP 100.
- Use SMA for heavy-traffic urban roads as per IRC SP 79, in place of bitumen mastic.
- Use CGBM on urban roads which are subjected to waterlogging and need frequent maintenance, wherever feasible. CGBM can be laid as per IRC SP 125.
- Use frequent watering, use stabilizers and dust suppressant, stockpile covers, and limit vehicle speeds during construction of pavement layers.

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**Annexure-1**

**Office Order F.No. A-110012/08/2020/CAQM-RD-1107/DT dated 21/11/2024**

**Annexure-2**

## List of Participants for the Meeting on 06.12.2024:

**CAQM**

1. Sh. Rajesh Verma, Chairperson
2. Dr. S. D. Attri, Member-Technical
3. Dr. Virinder Sharma, Member-Technical
4. Sh. Arvind Nautiyal, Member Secretary
5. Dr. Sujit Kumar Bajpayee, Member
6. Dr. Vikas Singh, Scientist – E
7. Dr. Dhananjay Kumar, Scientist – C
8. Sh. Vijay Kumar, Scientist – C

**Delhi Pollution Control Committee (DPCC)**

9. Dr. K. S. Jayachandran, Member-Secretary

**CSIR-CRRI, New Delhi**

10. Prof. Manoranjan Parida, Director
11. Dr. Niraj Sharma, Chief Scientist
12. Dr. C. Ravi Sekhar, Chief Scientist
13. Dr. Pradeep Kumar, Chief Scientist
14. Sh. Manoj Kumar Shukla, Senior Principal Scientist

**CSIR-NEERI, New Delhi**

15. Dr. S. K. Goyal, Chief Scientist & Head
16. Dr. Sunil Gulia, Senior Scientist

**Municipal Corporation of Delhi (MCD)**

17. Sh. Sudhir Kumar Mehta, Chief Engineer

**Public Works Department (PWD), GNCTD**

18. Sh. Manoj Kumar, Chief Engineer
19. Sh. Mukesh Kumar, Chief Engineer
20. Sh. K. Pradhan, Superintending Engineer

**School of Planning and Architecture, New Delhi**

21. Dr. Bidisha Chattopadhyay, Assistant Professor

**List of Participants for the Meeting on 13.12.2024**

**CAQM**

1. Sh. Rajesh Verma, Chairperson
2. Dr. Virinder Sharma, Member-Technical
3. Dr. Sujit Kumar Bajpayee, Member
4. Dr. Vikas Singh, Scientist – E
5. Dr. Dhananjay Kumar, Scientist – C
6. Sh. Vijay Kumar, Scientist – C

**CSIR-CRRI, New Delhi**

7. Prof. Manoranjan Parida, Director
8. Dr. C. Ravi Sekhar, Chief Scientist
9. Dr. Pradeep Kumar, Chief Scientist
10. Dr. Siksha Swavoopa Kar, Principal Scientist

**CSIR-NEERI, New Delhi**

11. Dr. S.K. Goyal, Chief Scientist & Head
12. Dr. Sunil Gulia, Senior Scientist

**School of Planning and Architecture, New Delhi**

13. Dr. Bidisha Chattopadhyay, Assistant Professor

**The Infravision Foundation**

14. Dr. Jagan Shah, Chief Executive Officer

**Delhi Pollution Control Committee (DPCC)**

15. Dr. K.S. Jayachandran, Member Secretary

**Municipal Corporation of Delhi (MCD)**

16. Sh. Santosh Kumar, Chief Engineer
17. Sh. Manoj Verma, Superintending Engineer
18. Sh. Pranav Suhag, Executive Engineer
19. Sh. Ankit Arya, Consultant

**Public Works Department (PWD), GNCTD**

20. Sh. Manoj Kumar, Chief Engineer, South Maintenance Zone
21. Sh. Shailendra, Chief Engineer, East Maintenance Zone
22. Sh. K. Pradhan, Superintending Engineer

**TPS Infrastructure Ltd.**

23. Sh. Varun Gupta, Senior Manager

**Kam-Avida Enviro Engineers Pvt. Ltd.**

24. Sh. Rahul Bharadwaj, Deputy General Manager

**List of Participants for the Meeting on 20.12.2024**

**CAQM**

1. Sh. Rajesh Verma, Chairperson
2. Dr. Sujit Kumar Bajpayee, Member
3. Sh. Arvind Kumar Nautiyal, Member Secretary
4. Sh. R.K. Agrawal, Director-Technical
5. Dr. Vikas Singh, Scientist – E
6. Dr. Dhananjay Kumar, Scientist – C
7. Sh. Vijay Kumar, Scientist – C

**CSIR-CRRI, New Delhi**

8. Prof. Manoranjan Parida, Director
9. Dr. C. Ravi Sekhar, Chief Scientist
10. Sh. Sunil Jain, Chief Scientist
11. Dr. Pradeep Kumar, Chief Scientist
12. Sh. Manoj Kumar Shukla, Senior Principal Scientist

**CSIR-NEERI, New Delhi**

13. Dr. S.K. Goyal, Chief Scientist & Head
14. Dr. Sunil Gulia, Senior Scientist

**School of Planning and Architecture, New Delhi**

15. Dr. Bidisha Chattopadhyay, Assistant Professor

**The Infravision Foundation**

16. Dr. Jagan Shah, Chief Executive Officer

**Delhi Pollution Control Committee (DPCC)**

17. Dr. Nandita Moitra, Scientist – D