

Lecture 5.38

5.5 Arboriculture

Introduction and Objectives of Highway Arboriculture

Arboriculture along highway rights-of-way involves the strategic planned cultivation of trees, shrubs, and groundcover plants tailored to the transportation environment.

Primary objectives include screening headlight glare on dual carriageways, delineating road alignment around horizontal curves, controlling wind erosion on embankments, dampening traffic noise in residential zones, absorbing tailpipe pollutants, and providing shade at rest areas.

- Functional Landscaping: Using vegetation for glare barrier and alignment guidance
- Environmental Protection: Preventing soil erosion and filtering vehicle emissions
- Aesthetic Improvement: Blending highway infrastructure with natural rural/urban landscapes
- Noise Mitigation: Dense green belts reducing sound transmission to nearby communities

Environmental Benefits: Emission and Air Quality Control

Vehicular exhaust releases harmful pollutants, including Particulate Matter ($PM_{2.5}$, PM_{10}), Carbon Monoxide (CO), Nitrogen Oxides (NO_x), and Unburnt Hydrocarbons (HC).

Roadside green belts act as bio-filters. Plant foliage captures airborne dust particles on leaf surfaces and absorbs gaseous pollutants, while dense tree canopies sequester CO_2 to offset the highway's carbon footprint.

- Particulate Trapping: Rough, hairy leaf surfaces filtering particulate dust ($PM_{2.5}$, PM_{10})
- Gaseous Absorption: Stomatal intake of NO_2 , SO_2 , and ground-level ozone
- Carbon Sequestration: Long-term biomass storage of carbon dioxide
- Microclimate Cooling: Transpiration cooling reducing urban heat island effects along black asphalt

Noise Attenuation and Buffer Belts

High-speed highway traffic generates substantial tire-pavement noise and engine roar, often exceeding permissible acoustic decibel limits for residential zones ($55dB(A)$).

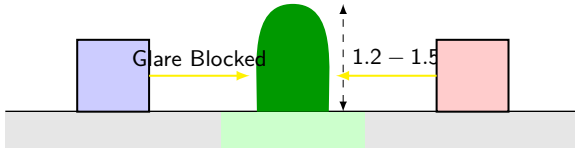
Strategically designed green belts consisting of multi-layered trees and evergreen dense shrubs can reduce traffic noise levels by 5 to 10 decibels (dB) through sound absorption, scattering, and refraction.

- Noise Reduction Mechanism: Leaves and branches absorb high-frequency tire sound waves
- Multi-Tier Design: Low shrubs at border, medium fruit trees, and tall canopy trees behind
- Buffer Belt Width: Minimum $10m$ – $15m$ wide dense vegetation strip for effective sound dampening
- Psychological Benefit: Visual obstruction of traffic reduces perceived noise annoyance

Median Landscaping for Headlight Glare Reduction

On dual carriageway highways, opposing high-beam headlights cause severe glare, temporarily blinding drivers traveling in opposite directions during night driving.

Planting dense, evergreen shrubs along the central median forms a continuous natural glare screen. Plants are maintained at a height of 1.2m to 1.5m above the pavement to block headlight rays while keeping sight lines clear across curves.

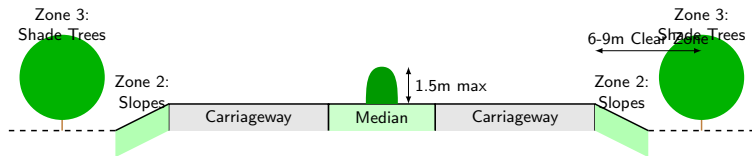


- Glare Screen Function: Blocking high-beam light paths from opposing lanes
- Evergreen Species Requirement: Retaining foliage year-round

Zonal Layout of Roadside Plantation

Highway rights-of-way (ROW) are divided into specific plantation zones to ensure trees do not interfere with overhead utilities, sight triangles, or structural shoulders.

The standard 3-tier layout consists of: 1. Median Zone (low shrubs up to 1.5m), 2. Inner Shoulder/Slope Zone (ground cover and grass for erosion control), and 3. Boundary Fence Zone (tall shade trees planted at least 6m to 9m away from the pavement edge).



Selection Criteria for Roadside Tree Species

Not all tree species are suitable for highway environments. Selecting inappropriate trees can create severe maintenance hazards and crash risks.

Criterion	Reason	Examples/Notes
Deep Taproots	Prevents lateral roots from cracking asphalt pavement	Avoid Ficus/Banyan near road
Non-Brittle Timber	Prevents branch snapping during monsoons & high winds	Neem, Arjun
Non-Edible Fruit	Avoids attracting cattle/monkeys onto lanes	Avoid Mango/Jamun
Evergreen Foliage	Retains leaves year-round, less sweeping required	Jacaranda
Drought/Exhaust Tolerance	Can survive harsh highway microclimate	Bougainvillea

Ideal Indian species include: Neem (*Azadirachta indica*), Jacaranda, Gulmohar, Amaltas, and Arjun.

Roadside Trees as Hazards and Forgiving Road Concepts

Large, rigid trees located close to the edge of high-speed travel lanes represent fatal fixed-object hazards for errant vehicles that leave the carriageway.

To satisfy 'Forgiving Road' concepts, highways mandate a Clear Zone (typically $6m - 9m$ wide free of unshielded rigid objects). If mature trees exist within the clear zone, W-beam crash barriers must be installed to shield vehicles from direct impact.

- Clear Zone Principle: Unobstructed recovery area provided adjacent to travel lanes
- Fixed-Object Hazard: Rigid trees with diameter $> 100mm$ can cause fatal impacts
- Shielding Mandate: Installing guardrails around existing legacy trees within clear zone
- Frangible Landscaping: Utilizing small-calibrated shrubs instead of heavy timber near lanes

Landscaping at Curves and Intersections

Vegetation placement at horizontal curves and grade intersections must be meticulously controlled to prevent obstructing vital driver sight triangles.

On the inside of horizontal curves, tall trees and dense shrubs must be kept clear within the sight line sight distance envelope. Conversely, planting trees along the outside perimeter of a curve provides excellent visual alignment delineation.

- Sight Triangle Protection: Keeping intersection sight corners completely clear of foliage above 0.6m
- Inside of Curves: Clearing tall vegetation to ensure full Stopping Sight Distance (SSD)
- Outside of Curves: Planting trees to visually outline curve geometry for night driving
- Vertical Clearance: Trimming lower tree branches up to 5.5m over travel lanes

Maintenance and Management of Highway Trees

Highway arboriculture requires continuous post-plantation maintenance to preserve traffic safety standards and ensure high plant survival rates.

Key maintenance operations include regular pruning of lower branches to maintain $5.5m$ vertical clearance over carriageways, trimming overgrown median shrubs, watering during early growth phases, clearing dead/diseased trees, and root pruning near drainage structures.

- Vertical Trimming: Maintaining $5.5m$ clear headroom for double-deck commercial trucks
- Median Pruning: Trimming median hedges to maintain $1.2m - 1.5m$ glare height
- Sight Distance Clearing: Quarterly trimming of foliage obscuring traffic signs and signals
- Tree Inventory Systems: Tagging roadside trees with GIS IDs for safety tracking

Environmental Impact Assessment (EIA) and Compensatory Afforestation

Highway widening projects often require felling legacy roadside trees, requiring mandatory Environmental Impact Assessment (EIA) clearance and forest department approvals.

Under national environmental regulations, Compensatory Afforestation mandates planting new trees at a 1:3 or 1:5 ratio for every tree felled (i.e., planting 3 to 5 saplings per felled tree) along project corridors or designated forest land.

- EIA Requirement: Mandatory environmental clearance for major highway expansion projects
- Tree Felling Approvals: Permissions required under Forest Conservation Act
- Compensatory Ratio: Planting 3 to 5 new saplings for every 1 mature tree removed
- 5-Year Maintenance Contract: Ensuring survival rates $> 80\%$ for compensatory plantations

Summary of Arboriculture

This lecture covered the principles, environmental benefits, median glare control, species selection, and safety clear-zone requirements of highway arboriculture.

Properly engineered roadside arboriculture balances environmental sustainability (carbon capture, noise reduction, soil binding) with roadside safety (glare screening, clear zones, sight triangle protection).

- Arboriculture transforms roadside vegetation into functional engineering safety assets
- Median shrub planting (1.2 – 1.5m) eliminates oncoming high-beam headlight glare
- Species selection prioritizes deep taproots, non-brittle wood, and non-edible fruit
- Clear Zones (6 – 9m) protect errant vehicles from colliding with rigid tree trunks
- Compensatory afforestation (1:3 to 1:5 ratio) mitigates tree felling during highway widening