

TRANSPORTATION ENGINEERING

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CIVIL

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TRANSPORTATION ENGINEERING - WEEK 3 COMPLETE NOTES

Cross Sectional Elements of Roads

Definition

The cross-section of a road represents the transverse view perpendicular to the centerline, showing all structural and functional components from one edge to the other. Cross-sectional elements include the carriageway width, cross slope (camber), medians, kerbs, shoulders, footpaths, and other roadside facilities. These elements are designed based on traffic volume, vehicle characteristics, safety requirements, drainage needs, and functional classification of the road. Proper cross-sectional design ensures safe vehicular movement, adequate drainage, pedestrian facilities, and future expansion possibilities while maintaining structural integrity and cost-effectiveness.

Explanation (8 key points)

1. Cross-section design varies based on road classification and traffic requirements.
2. Carriageway width accommodates design vehicles and traffic volume safely.
3. Cross slope (camber) facilitates surface water drainage preventing hydroplaning.
4. Medians separate opposing traffic streams enhancing safety.
5. Kerbs define pavement edges and control surface drainage.
6. Shoulders provide emergency stopping space and lateral support to pavement.
7. Right-of-way accommodates present facilities and future expansion needs.
8. Cut and fill slopes must be stable and properly drained.

Real-Life Example

The Delhi-Meerut Expressway features a comprehensive cross-section with 14-lane divided carriageway, wide medians, paved shoulders, service roads, and adequate ROW for utilities and future expansion.

1. Cross Slope or Camber

Definition

Cross slope or camber is the transverse slope provided across the carriageway to facilitate quick drainage of rainwater from the road surface. It prevents water stagnation that can cause pavement damage, hydroplaning, and reduced skid resistance.

Types of Camber

1. Straight Camber (Crowned):

The road surface slopes uniformly from the centerline to both edges, forming two inclined planes meeting at the crown. This is the most common type used on divided highways and provides equal drainage to both sides. The highest point is at the centerline, and water drains toward the shoulders or side drains.

2. Parabolic Camber:

The road surface follows a parabolic curve from the centerline to the edges. This provides a smoother riding surface compared to straight camber, especially at higher speeds. The gradual curvature reduces vehicle oscillations and improves passenger comfort. It is commonly used on expressways and high-speed roads.

3. Sloped Camber:

The entire carriageway width slopes uniformly in one direction from one edge to the other. This is used in urban areas where side drainage is constrained or where the road runs along a hillside. It simplifies drainage collection but may cause vehicles to drift toward the lower edge.

IRC Recommendations for Camber

The amount of camber depends on the type of road surface:

Surface Type	Camber (%)	Remarks
Cement Concrete	1.5 - 2.0	Smooth, impervious surface requires less camber
Bituminous Surface	2.0 - 2.5	Standard for most highways
Water Bound Macadam (WBM)/Gravel	2.5 - 3.0	More porous surface needs steeper slope

Earth Roads	3.0 - 4.0	Highly permeable, requires maximum camber
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Functions of Camber

- Rapid Water Drainage:** Prevents water accumulation on the pavement surface.
- Pavement Protection:** Reduces water infiltration into the pavement structure, preventing premature failure.
- Hydroplaning Prevention:** At high speeds, adequate camber prevents loss of tire contact with pavement.
- Improved Visibility:** Better drainage improves visibility during rain by reducing spray.
- Structural Integrity:** Protects the pavement base and subgrade from moisture damage.
- Skid Resistance:** Maintains tire-pavement friction by removing water film.

Design Considerations

- Steeper camber increases construction difficulty and cost.
- Excessive camber causes vehicle drift and discomfort.
- Camber transitions must be gradual, especially at curves with superelevation.
- Urban roads may use single-slope camber for ease of drainage collection.
- Camber is eliminated gradually when superelevation is introduced on curves.

2. Width of Carriageway

Definition

Carriageway width is the paved portion of the roadway used for vehicular traffic movement, measured from kerb to kerb or edge to edge of the traveled way. It excludes shoulders, parking lanes, and footpaths.

Factors Affecting Carriageway Width

1. Design Vehicle Dimensions:

The width must accommodate the largest vehicle expected to use the road regularly. In India, IRC considers standard vehicle dimensions including trucks, buses, and agricultural vehicles.

2. Traffic Volume and Composition:

Higher traffic volumes require multiple lanes. Mixed traffic with different vehicle

types needs additional width for safe maneuvering. Peak hour traffic demand determines the number of lanes required.

3. Design Speed:

Higher design speeds require wider lanes for driver comfort and safety. At 100 km/h, drivers need more lateral clearance than at 50 km/h. Lane widths of 3.5m are standard for speeds above 80 km/h.

4. Multi-lane Requirements:

Multi-lane highways need consistent lane widths for all lanes. Inner lanes may be slightly narrower (3.25m) if space is constrained, but outer lanes should remain 3.5m for safety.

5. Overtaking and Maneuvering:

Two-lane roads need sufficient width for safe overtaking. Three-lane roads provide a middle lane for overtaking. Inadequate width forces vehicles too close, increasing accident risk.

6. Sight Distance:

On horizontal curves, additional width may be needed to improve sight distance around the inside of curves.

7. Economic Considerations:

Wider pavements cost more to construct and maintain. The design must balance safety, capacity, and cost.

8. Available Right-of-Way:

Existing road widening projects are constrained by available ROW and acquisition costs.

IRC Standards for Carriageway Width

Rural Areas:

Road Classification	Lanes	Carriageway Width
National Highway (Expressway)	4-8 lanes	4 lanes: 14.0m (2×7.0m) 6 lanes: 21.0m
National Highway	2 lanes	7.0m
State Highway	2 lanes	7.0m
Major District Road	2 lanes	7.0m
Other District Road	1-2 lanes	5.5m (intermediate) 7.0m (2-lane)
Village Road	Single lane	3.75m

Urban Areas:

Road Classification Carriageway Width Remarks

Arterial Roads	14.0m - 28.0m	4-8 lanes depending on traffic
Sub-arterial Roads	10.5m - 14.0m	3-4 lanes
Collector Streets	7.0m - 10.5m	2-3 lanes
Local Streets	5.5m - 7.0m	1-2 lanes

Standard Lane Widths:

- Expressways and National Highways:** 3.5m per lane
- State Highways:** 3.5m per lane
- District Roads:** 3.5m (2-lane), 3.0-3.5m (single lane)
- Village Roads:** 3.75m (single lane with passing places)
- Urban Streets:** 3.0-3.5m per lane depending on design speed

Special Width Requirements
At Bridges:

Carriageway width on bridges should ideally match the approach road width. If constrained, minimum clear width should be:

- 2-lane: 7.5m clear between kerbs
- Single lane: 4.25m clear

At Tunnels:

Additional width (0.25-0.50m per lane) may be provided for psychological comfort in enclosed spaces.

At Intersections:

Approach widths may need widening for turning lanes, acceleration/deceleration lanes, and pedestrian refuge islands.

3. Medians

Definition

A median is the central reserve or divider separating opposing traffic streams on divided highways. It serves as a physical and psychological barrier, preventing head-on collisions and providing space for various safety and operational functions.

Types of Medians

1. Raised Median:

Description:

A median physically elevated above the carriageway level, typically with vertical kerbs on both sides. The raised surface can be paved, planted with grass/shrubs, or a combination.

Construction:

- Kerb height: 150-225mm above carriageway
- Median surface: Concrete, brick paving, or vegetated
- May include crash barriers or guardrails

Advantages:

- Maximum traffic separation and safety
- Prevents wrong-way driving
- Accommodates street lights, signs, and utilities
- Reduces headlight glare effectively
- Provides space for landscaping and aesthetics
- Can accommodate emergency crossovers

Disadvantages:

- Higher construction cost
- Difficult for emergency vehicles to cross
- Maintenance requirements for vegetation
- May trap debris and require cleaning

2. Depressed Median:

Description:

A median lower than the adjacent carriageway, functioning as a drainage channel as well as a separator.

Construction:

- Depth: 150-300mm below carriageway
- Side slopes: 4:1 to 6:1 for vehicle traversability in emergencies
- May be grass-lined or paved

Advantages:

- Serves dual purpose: separation and drainage
- Lower construction cost than raised median

- Easier for emergency vehicle crossing
- Reduces need for separate drainage structures

Disadvantages:

- Less effective psychological barrier
- Standing water may be hazardous
- Requires regular drainage maintenance
- Limited space for utilities and landscaping
- May fill with debris and sediment

3. Flush Median:

Description:

A median at the same level as the carriageway, marked only with pavement markings, paint, or different colored surfacing material.

Construction:

- Level with carriageway
- Marked with double yellow lines or hatching
- May use different pavement texture or color

Advantages:

- Lowest construction cost
- Maximum flexibility for traffic management
- Easy emergency vehicle crossing
- Can be converted to turning lanes when needed

Disadvantages:

- Minimal physical separation
- Easily violated by drivers
- No space for utilities or landscaping
- No headlight glare reduction
- Requires good driver discipline

Functions of Medians

1. Traffic Separation:

Provides physical and visual separation between opposing traffic flows, drastically reducing head-on collisions which are typically the most severe accident type.

2. Emergency Recovery:

Gives errant vehicles space to recover without crossing into opposing traffic. The median acts as a safety buffer zone.

3. Pedestrian Refuge:

At intersections and crossings, medians provide a safe waiting area for pedestrians crossing wide roads in two stages.

4. Access Control:

Controls turning movements and prevents mid-block U-turns, improving traffic flow and safety. Openings are provided only at designated intersections.

5. Utility Accommodation:

Raised medians provide space for street lighting, traffic signals, utility lines (telecom, power), and signage without encroaching on the traveled way.

6. Glare Reduction:

Physical barriers and vegetation in medians reduce headlight glare from oncoming traffic, improving nighttime driving comfort and safety.

7. Aesthetic Enhancement:

Landscaped medians with trees, shrubs, and flowers improve visual appeal, reduce driver fatigue on long trips, and enhance urban environment quality.

8. Emergency Services:

Can accommodate emergency crossovers for police, ambulance, and fire services, though this is carefully controlled.

IRC Standards for Median Width

Minimum Widths:

- **Urban Expressways:** 5.0-10.0m (allows landscaping and utilities)
- **Rural Expressways:** 3.0-5.0m
- **Urban Arterials:** 3.0-5.0m
- **Absolute Minimum:** 1.2m (for painted median with no facilities)

Desirable Widths:

- For landscaping and trees: 5.0-10.0m
- For utilities only: 3.0-5.0m
- For basic separation: 2.0-3.0m

At Intersections:

Medians may be widened to 7.0-15.0m to accommodate left-turn lanes, traffic signal equipment, and pedestrian refuge islands.

Median Openings:

- Spacing: Minimum 1.5-2.0 km on expressways
- Width: 12-15m for U-turns
- Design: Bullet-nose or tapered ends with guardrails

Design Considerations

Safety:

- Kerb height should not cause vehicle rollover
- End treatments (nose) must be crashworthy
- Adequate sight distance across medians at intersections

Drainage:

- Raised medians need drainage inlets
- Depressed medians must have adequate capacity and outlets

Maintenance:

- Access for mowing, cleaning, and utility repairs
- Vegetation selection for low maintenance

Utilities:

- Coordinate location of underground and overhead utilities
- Provide access manholes where required

4. Kerbs

Definition

Kerbs (or curbs) are vertical or sloped edge treatments along the boundaries of pavements, defining the limits of the carriageway and providing lateral confinement, drainage control, and pedestrian protection.

Types of Kerbs

1. Barrier Kerb (High Kerb):

Description:

A kerb with a near-vertical face, typically 150-200mm in height, designed to discourage or prevent vehicles from leaving the carriageway.

Dimensions:

- Height: 150-225mm above gutter
- Face angle: Vertical or slight batter (80-90°)
- Width: 300-450mm at base

Applications:

- Urban streets separating vehicular and pedestrian areas
- Medians on divided highways
- Bridge edges and elevated roadways
- Areas requiring strict traffic control
- Parking lot boundaries

Advantages:

- Effectively deters vehicle encroachment
- Clear delineation of pavement edge
- Protects pedestrians and property
- Controls surface drainage effectively

Disadvantages:

- Can damage vehicle wheels/tires if struck
- Potential for vehicle instability if mounted at speed
- Emergency vehicle crossing difficult
- Traps debris and requires cleaning

2. Mountable Kerb (Semi-Barrier Kerb):

Description:

A kerb with a sloped face allowing occasional vehicle crossing in emergencies while still providing edge definition and drainage control.

Dimensions:

- Height: 75-125mm
- Face angle: 45° typical

- Top width: 75-150mm
- Base width: 300-400mm

Applications:

- Rural highways and state roads
- Residential streets allowing driveway access
- Areas where occasional vehicle crossing is acceptable
- Locations near emergency services

Advantages:

- Permits emergency vehicle crossing
- Less severe impact if struck at moderate speed
- Provides drainage control
- Marks pavement edge clearly
- Lower construction cost than barrier kerb

Disadvantages:

- Less effective at preventing encroachment
- Can still damage vehicles if struck hard
- May encourage unauthorized parking or driving
- Requires wider shoulder/verge space

3. Submerged Kerb (Flush Kerb):

Description:

A kerb installed at or slightly above the same level as the adjacent pavement, relying primarily on material or color difference for edge definition.

Dimensions:

- Height: 0-25mm above pavement
- Width: 150-300mm
- Marked with different material or color

Applications:

- Driveway crossings
- Bus stops and loading zones
- Locations requiring frequent vehicle crossing

- Parking areas and service stations
- Areas with high drainage capacity needs

Advantages:

- No obstruction to vehicle crossing
- Minimal impact on vehicle if crossed
- Simple construction
- Good for accessibility (wheelchairs, prams)

Disadvantages:

- Poor edge definition
- Easily ignored by drivers
- Limited drainage control
- May permit unauthorized encroachment
- Less pedestrian protection

Functions of Kerbs**1. Edge Definition:**

Clearly marks the boundary between carriageway and shoulder/footpath, providing visual guidance especially at night and in poor weather.

2. Lateral Pavement Support:

Provides structural confinement to the pavement edge, preventing lateral spreading of the base and surface materials under traffic loads.

3. Drainage Control:

Channels surface water along the kerb line to drainage inlets, preventing water from flowing off the road at random locations and causing erosion.

4. Pedestrian Protection:

Barrier kerbs create a physical and psychological barrier between vehicles and pedestrian areas, improving safety.

5. Aesthetic Function:

Neat, well-maintained kerbs enhance the visual appearance of roads and urban streetscapes.

6. Access Control:

Helps control vehicle access points by making casual entry/exit difficult except at designated driveways and intersections.

7. Snow Storage:

In cold climates, kerbs contain plowed snow, keeping carriageways clear.

Materials for Kerb Construction**1. Stone Kerbs:**

- Natural granite, sandstone, or limestone
- High durability (50+ years)
- Expensive initial cost
- Used in heritage areas and premium projects
- Requires skilled masonry

2. Precast Concrete Kerbs:

- Factory-made standard units
- Consistent quality and dimensions
- Moderate cost
- Easy and fast installation
- Most common in modern construction
- Typical life: 30-40 years

3. Cast-in-Place Concrete Kerbs:

- Poured on-site using formwork
- Custom shapes and dimensions possible
- Integral bond with pavement
- Labor-intensive installation
- Good for curved sections
- Cost-effective for large projects

4. Asphalt Kerbs:

- Temporary or low-cost applications
- Easy to install and modify
- Short lifespan (5-10 years)
- Limited structural support
- Used in parking lots and temporary roads

Design Considerations

Geometric Design:

- Height appropriate for intended function
- Face slope for mountability (if required)
- Adequate width for stability
- Smooth transitions at driveways

Drainage:

- Kerb face openings or weep holes where needed
- Coordinate with drainage inlet spacing
- Prevent water ponding against kerb

Joints and Expansion:

- Expansion joints every 5-10m
- Contraction joints at 1-2m intervals
- Proper sealing to prevent water infiltration

Durability:

- Adequate concrete strength (M20 minimum)
- Reinforcement in curved sections
- Weather-resistant materials in harsh climates

Road Margins and Roadside Facilities

1. Shoulders

Definition

Shoulders are the portions of the roadway adjacent to and contiguous with the carriageway, designed to provide space for emergency stops, lateral structural support to the pavement, and accommodation of safety features like guardrails. They form a critical safety element allowing disabled vehicles to move out of traffic flow.

Functions of Shoulders

1. Emergency Stopping:

Provides safe space for vehicles experiencing mechanical breakdown, flat tires, or

driver illness. This prevents stopped vehicles from obstructing traffic lanes and causing secondary accidents.

2. Structural Support:

Shoulders confine the pavement structure laterally, preventing edge failure and rutting. The shoulder distributes traffic loads that approach the pavement edge, extending pavement life.

3. Maintenance Operations:

Provides space for maintenance vehicles and equipment during routine operations like mowing, sign repair, and pothole patching without closing traffic lanes.

4. Improved Sight Distance:

On horizontal curves, clear shoulders improve sight distance by removing obstructions. Drivers can see further around curves when shoulders are properly maintained.

5. Lateral Clearance:

Creates a buffer zone between the traveled lane and roadside hazards like trees, poles, and ditches. This "clear zone" allows errant vehicles to recover safely.

6. Accommodation of Appurtenances:

Provides space for guardrails, traffic signs, delineators, and mailboxes without encroaching on the traveled way.

7. Emergency Vehicle Access:

Allows police, ambulance, and fire vehicles to bypass congested traffic during emergencies.

8. Reduced Driver Stress:

The presence of adequate shoulders reduces driver anxiety about edge dropoffs, creating a more comfortable driving experience and reducing fatigue.

Types of Shoulders

1. Paved Shoulders (Surfaced Shoulders):

Description:

Shoulders constructed with the same or similar surface material as the carriageway, typically bituminous or concrete pavement.

Construction:

- Surface: Bituminous concrete (BC) or Portland cement concrete (PCC)
- Base: Similar to pavement base structure
- Thickness: 50-75% of main pavement thickness

Where Used:

- National Highways and expressways
- High-volume State Highways
- Urban arterial roads
- Bridges and elevated structures (full paved shoulders)

Advantages:

- Best structural support for pavement edge
- Can support full vehicle loads in emergencies
- Minimal edge differential with pavement
- Easier maintenance (sweeping, cleaning)
- Better for high-speed emergency stops
- Can be used for future widening
- Better drainage (when properly sloped)

Disadvantages:

- Higher initial construction cost
- May encourage unauthorized use as travel lane
- Requires regular maintenance (crack sealing, patching)
- Heat absorption can be problematic

2. Granular Shoulders (Gravel Shoulders):**Description:**

Shoulders surfaced with well-graded gravel, crushed stone, or other granular materials, providing moderate strength and drainage.

Construction:

- Surface: Compacted gravel or crushed aggregate
- Thickness: 100-150mm compacted
- Material: Well-graded crushed stone or gravel

Where Used:

- Most State Highways and Major District Roads
- Rural highways with moderate traffic
- Areas with lower construction budgets
- Interim surface before final paving

Advantages:

- Lower construction cost than paved
- Adequate for most emergency stopping needs
- Good drainage characteristics
- Natural appearance in rural settings
- Easy to repair and maintain
- Discourages use as travel lane

Disadvantages:

- Requires frequent maintenance (grading, re-graveling)
- Erosion during heavy rains
- Dust generation in dry conditions
- Less structural support than paved
- Edge drop-off can develop
- Limited load capacity for heavy vehicles

3. Grass or Turf Shoulders:**Description:**

Shoulders vegetated with grass or other ground cover, providing erosion control and a natural appearance.

Construction:

- Topsoil layer: 75-150mm
- Seed or sod grass
- Regular mowing and maintenance required

Where Used:

- Low-volume rural roads
- Village roads and Other District Roads
- Areas with good rainfall and growing conditions
- Scenic byways and parkways

Advantages:

- Lowest construction cost
- Excellent erosion control when established

- Aesthetically pleasing
- Filters rainwater runoff
- Minimal dust generation
- Sustainable and environmentally friendly

Disadvantages:

- Limited load capacity
- Can become muddy when wet
- Requires regular mowing
- Not suitable for frequent use
- Seasonal appearance variations
- Poor for emergency stopping in wet conditions

IRC Standards for Shoulder Width

Rural Highways:

Road Classification	Paved Shoulder (Each Side)	Granular Shoulder (Each Side)	Total Shoulder Width
NH (4-lane divided)	3.0m	-	6.0m (both sides)
NH (2-lane)	1.5m	2.5m	4.0m (total width each side)
State Highway	1.5m	2.5m	4.0m
Major District Road	1.0m	2.0m	3.0m
Other District Road	-	1.5m	1.5m
Village Road	-	1.0m	1.0m

Urban Roads:

Road Type	Paved Shoulder Width	Remarks
Urban Expressway	2.5-3.0m	Full paved width
Arterial Roads	1.5-2.5m	May include parking function
Sub-Arterial	1.0-1.5m	Often combined with parking

Local Streets	0.5-1.0m or kerb only	Limited shoulder space
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Design Considerations

Cross Slope:

- Paved shoulders: Same slope as carriageway (2-2.5%)
- Granular shoulders: Slightly steeper (3-4%) for better drainage
- Grass shoulders: 4-6% slope

Edge Drop-Off:

- From carriageway to shoulder: Maximum 75mm
- From shoulder to roadside: Maximum 150mm
- Gradual transitions preferred

Surface Treatment:

- Paved shoulders should tie into pavement (no longitudinal joint separation)
- Different texture or color to discourage regular use
- Rumble strips may be added for driver alert

Structural Design:

- Paved shoulders: 50-75% of pavement thickness
- Must support occasional heavy vehicle loads
- Edge support critical for pavement integrity

Width Transitions:

- Gradual narrowing at bridges (if required)
- Adequate width maintained on curves
- Wider shoulders on long, steep grades

2. Guard Rails

Definition

Guard rails are longitudinal barriers installed along the roadside to shield vehicles from roadside hazards, prevent vehicles from leaving the roadway, and redirect errant vehicles back onto the road safely.

When Guard Rails are Required

Guard rails should be installed when:

- **Steep Embankments:** Fill height exceeds 3-4 meters
- **Water Bodies:** Adjacent to rivers, canals, lakes
- **Fixed Objects:** Trees, poles, bridge piers near roadway
- **Sharp Curves:** Limited sight distance curves at high speeds
- **Bridge Approaches:** Transition from open road to bridge
- **Medians:** Narrow medians on high-speed roads
- **Cliffs and Drop-offs:** Mountain roads with precipitous edges

Types of Guard Rails

1. Flexible Guard Rail Systems:

W-Beam Steel Rail:

- Most common type
- Corrugated steel W-shaped beam (310mm height)
- Mounted on steel or wooden posts (typically 2m apart)
- Rails mounted at 750mm height
- Deflects 0.5-1.5m when impacted
- Absorbs energy through deformation

Cable Barrier:

- Three to four steel cables tensioned between posts
- Post spacing: 3-5m
- Lowest cost barrier system
- Maximum deflection but good energy absorption
- Used on median barriers and low-traffic roads

Advantages:

- Lower cost than rigid barriers
- Easy installation and repair
- Good energy absorption
- Gradual vehicle redirection

Disadvantages:

- Large deflection requires clear space behind

- Not suitable where deflection space limited
- Requires regular maintenance and tension adjustment
- Can be dangerous for motorcyclists

2. Semi-Rigid Guard Rail Systems:

Box Beam Barriers:

- Rectangular hollow steel sections
- Stronger than W-beam
- Less deflection (0.3-0.8m)
- Higher cost

Thrie-Beam Barriers:

- Three-wave corrugated beam
- Greater height and strength than W-beam
- Used for truck protection
- Moderate deflection

3. Rigid Guard Rail Systems:

Concrete Barriers (Jersey Barriers):

- Precast or cast-in-place concrete
- Typically 810-1000mm height
- Distinctive sloped face profile (New Jersey profile)
- Zero deflection
- Redirects vehicles upward and away

F-Shape Barriers:

- Similar to Jersey but steeper lower slope
- Better for passenger cars
- Prevents vehicle underride

Advantages of Rigid Barriers:

- No deflection - suitable for limited space
- Very durable (50+ year life)
- Low maintenance

- Can incorporate drainage
- Not affected by vehicle impacts

Disadvantages:

- Highest cost
- Heavy and difficult to install
- Can cause severe vehicle damage
- Difficult to modify or remove

IRC Recommendations

Installation Criteria:

- Embankment height > 3m: Consider installation
- Embankment height > 6m: Mandatory installation
- Clear zone not available: Install barriers

Barrier Height:

- Standard height: 750mm for passenger vehicles
- Truck barriers: 1000-1200mm

Length of Need:

- Extends beyond hazard at both ends
- Flared end treatments or terminals

End Treatments:

- Buried terminals
- Crash cushions
- Turned-down ends (away from traffic)

3. Footpaths (Sidewalks)

Definition

Footpaths or sidewalks are paved areas dedicated exclusively to pedestrian traffic, separated from vehicular traffic by kerbs or other physical barriers. They form an essential component of urban transportation infrastructure, ensuring pedestrian safety and mobility.

Importance of Footpaths

Safety:

Physical separation from fast-moving vehicles reduces pedestrian accidents significantly. Studies show pedestrian fatality risk increases dramatically when pedestrians share roadway with vehicles.

Accessibility:

Provides mobility for all population segments including children, elderly, disabled persons, and those without access to vehicles.

Encourages Walking:

Quality footpaths encourage walking for short trips, reducing traffic congestion and vehicle emissions. Walking promotes public health.

Social Interaction:

Sidewalks serve as social spaces where neighbors interact, children play (in residential areas), and community bonds form.

Economic Activity:

In commercial areas, footpaths facilitate window shopping, access to businesses, and economic activity. Street vendors often operate from footpath edges.

Environmental Benefits:

Encouraging walking reduces carbon footprint, air pollution, and urban heat island effects.

Design Standards for Footpaths**Width Requirements:**

The width depends on pedestrian volume and area characteristics:

Area Type	Minimum Width	Desirable Width	Remarks
Residential (Low Density)	1.5m	2.0m	Two persons passing
Residential (High Density)	2.0m	2.5m	Moderate foot traffic
Commercial Areas	3.0m	4.0-5.0m	High pedestrian volumes
Near Schools	2.5m	3.0m	Student safety
Near Hospitals	2.5m	3.0m	Wheelchair access
Industrial Areas	1.5m	2.0m	Lower pedestrian volumes

Clear Width:

The stated width should be clear of all obstructions (poles, trees, fire hydrants, signboards).

Surface Requirements:**Material Selection:**

- **Concrete:** Most common, durable, smooth
- **Interlocking Concrete Pavers:** Attractive, permeable options available, easy repair
- **Stone/Granite Slabs:** Durable, premium appearance, expensive
- **Asphalt:** Lower cost, less durable, heat absorption
- **Brick Pavers:** Traditional, moderate durability

Surface Characteristics:

- **Non-slip:** Textured finish, especially important in wet climates
- **Smooth but not polished:** Prevents wheelchair difficulty
- **Well-drained:** Prevent water pooling
- **Stable and firm:** No shifting or settlement
- **Weather-resistant:** Withstand local climate

Cross Slope:

- Maximum: 2% for drainage
- Minimum: 1% to prevent ponding
- Consistent slope along length

Longitudinal Slope:

- Follow road gradient generally
- Maximum: 5% preferred, 8.3% absolute maximum
- Ramps at steeper sections with handrails

Accessibility Features (Universal Design):**Kerb Ramps:**

- Required at all intersections and mid-block crossings
- Slope: Maximum 1:12 (8.3%)
- Width: Minimum 1.8m

- Landing at top: 1.5m × 1.5m minimum
- Detectable warning surface (tactile indicators)

Tactile Paving:

- Textured surface for visually impaired
- At crossing points and hazards
- Different patterns indicate different warnings
- Contrasting color

Obstructions:

- Maintain clear width free of poles, signs, vendors
- Overhead clearance: Minimum 2.4m
- Identify and mark unavoidable obstacles

Resting Places:

- Benches every 100-200m for elderly
- Shaded seating areas

Separation from Carriageway:

Physical Separation:

- **Raised Kerb:** 150-200mm height
- **Bollards or Planters:** Where kerb impractical
- **Planted Verge/Buffer Strip:** 0.5-1.5m width, provides additional safety and aesthetics

Buffer Zone:

Desirable to have vegetated strip or furniture zone between kerb and footpath:

- Tree planting strip: 1.5-2.0m
- Street furniture zone: 0.5-1.0m
- Provides additional safety buffer
- Accommodates street trees, lights, benches, bicycle racks

Additional Features:

Lighting:

- Adequate illumination for night safety
- Spacing: 25-30m in urban areas

- Minimum illumination: 10-20 lux

Drainage:

- Cross-slope toward kerb
- Kerb inlets at low points
- Avoid water flowing across footpath

Street Furniture:

- Benches, bins, bicycle parking
- Locate in furniture zone, not obstructing path
- Weather-resistant materials

Tree Planning:

- Shade is critical in hot climates
- Tree grates or sufficient soil volume
- Choose species with non-invasive roots
- Adequate clearance from overhead wires

4. Driveways

Definition

Driveways are vehicle access connections between public roads and private properties (residential, commercial, or industrial), designed to allow safe entry and exit while minimizing disruption to through traffic.

Design Considerations

Width:

- **Residential Single Car:** 3.0-3.5m
- **Residential Double Car:** 4.5-6.0m
- **Commercial:** 6.0-9.0m
- **Industrial (Heavy Vehicles):** 7.0-12.0m with turning radii

Slope:

- **Maximum Longitudinal Slope:**
 - Residential: 15% (8.5° angle)
 - Commercial: 10%

- Industrial: 8%
- **Transition Slope:** 3-5m length at steeper grades
- **Cross Slope:** 2% for drainage

Sight Distance:

- At driveway-road junction: Adequate visibility in both directions
- Minimum stopping sight distance for approaching traffic
- Clear sight triangle: 3m × 3m clear of obstructions above 0.6m height

Pavement:

- Residential: Concrete, pavers, asphalt
- Commercial/Industrial: Reinforced concrete for heavy loads
- Minimum thickness: 100mm concrete, 75mm asphalt

Kerb Modifications:

- Mountable kerb at driveway crossing
- Gradual transitions to avoid vehicle scraping
- Maintain footpath continuity across driveway

Drainage:

- Slope away from road to prevent water flowing onto public road
- Drain to property or collection system
- Gutter/drain at street interface

Spacing (in Urban Areas):

- Minimum spacing between driveways: 6-10m
- Setback from intersections: 15-30m

5. Cycle Tracks

Definition

Cycle tracks are dedicated facilities for bicycle traffic, either segregated from or integrated with motor vehicle traffic, designed to provide safe and efficient bicycle mobility.

Importance

- **Safety:** Separates vulnerable cyclists from fast-moving motor traffic

- **Encourages Cycling:** Safer infrastructure increases bicycle mode share
- **Environmental:** Promotes zero-emission transportation
- **Health:** Encourages physical activity and public health
- **Congestion Relief:** Bicycles occupy less road space than cars

Types of Cycle Tracks

1. Segregated Cycle Track (Protected Bike Lane):

- Physically separated from motor traffic by kerb, bollards, or barrier
- Separate pavement structure and surface
- Highest level of safety and comfort
- Requires additional right-of-way

2. Cycle Lane (Marked Lane):

- Marked lane within the roadway using pavement markings and paint
- Shares the same pavement structure as vehicle lanes
- Lower cost than segregated tracks
- Requires good driver discipline and enforcement

3. Shared Path:

- Cyclists and pedestrians share the same facility
- Common in parks and recreational areas
- Lower speeds, potential conflicts
- Requires adequate width and clear markings

4. On-street Parking Protected:

- Cycle track located between parking lane and kerb
- Parked cars provide buffer from moving traffic
- Urban streets with on-street parking

Design Standards (IRC and Indian Context)

Width Requirements:

Facility Type	Minimum Width	Desirable Width	Remarks
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One-way Cycle Track	2.0m	2.5m	Single file plus passing
Two-way Cycle Track	3.0m	3.5-4.0m	Two directions of travel
Cycle Lane (on-road)	1.5m	2.0m	Within roadway
Shared Pedestrian-Cycle Path	3.0m	4.0m	Low speeds

Geometric Design:

Horizontal Alignment:

- Minimum curve radius: 10m (desirable: 20m)
- Avoid sharp turns requiring cyclists to slow significantly
- Banking on curves not typically provided

Vertical Alignment:

- Maximum gradient: 3% desirable, 5% acceptable
- Steep sections: 8% maximum for short lengths (<50m)
- Ramps at grade changes

Cross Slope:

- 1-2% for drainage
- Avoid excessive slope causing bicycle drift

Surface:

- **Smooth:** Avoid rough textures uncomfortable for cycling
- **Non-slip:** Important in wet conditions
- **Well-maintained:** Free of potholes, cracks
- **Materials:** Asphalt or smooth concrete preferred

Separation from Motor Traffic:

Physical Barriers:

- Kerbs: 100-150mm height
- Bollards: Spaced 1.2-1.5m apart
- Planters or landscaped buffer
- Concrete barriers on high-speed roads

Buffer Width:

- Minimum: 0.5m
- Desirable: 1.0-1.5m
- Provides safety clearance from moving vehicles

Pavement Markings:

- Bicycle symbol at regular intervals (50m)
- Directional arrows
- Edge lines (white for separated)
- Colored surface (typically red or green) for visibility

Intersections and Crossings:

Signal Priority:

- Separate signal phase for bicycles if volumes warrant
- Bicycle-actuated signals
- Advanced green for bicycles

Crossing Design:

- Marked bicycle crossings at intersections
- Raised crossings for visibility
- Refuge islands on wide roads

Sight Distance:

- Clear visibility at driveways and intersections
- Trim vegetation regularly

Conflict Zones:

- Alert drivers to expect crossing cyclists
- Reduce vehicle speeds
- Colored pavement treatments

Additional Features:

Lighting:

- Adequate illumination for night cycling safety
- Minimum 10 lux in urban areas

Signage:

- Direction signs to key destinations
- Distance markers
- Warning signs at hazards

Bicycle Parking:

- Secure parking facilities at destinations
- Short-term: Bicycle racks
- Long-term: Enclosed parking with security

Maintenance:

- Regular sweeping to remove debris and broken glass
- Prompt pothole repairs
- Snow/leaf removal

6. Parking Lanes**Definition**

Parking lanes are designated areas within or adjacent to the roadway for temporary vehicle storage, either parallel or angled to the traffic flow.

Types of Parking**1. Parallel Parking:**

- Vehicles park parallel to the roadway edge
- Most space-efficient for narrow roads
- Slower ingress/egress movements

Dimensions:

- Width required: 2.0-2.5m
- Length per vehicle: 5.5-6.0m (typical car)
- Length per vehicle: 8.0-10.0m (trucks/buses)

2. Angle Parking ($30^\circ, 45^\circ, 60^\circ, 90^\circ$):

- Vehicles park at an angle to the roadway
- Faster ingress/egress

- More parking capacity per linear meter
- Requires wider roadway

Dimensions (for 90° Parking):

- Width per vehicle: 2.5m
- Depth required: 5.0m (typical car)
- Maneuvering aisle width: 6.0-7.0m

Angle Parking Width Requirements:

- 30° parking: 3.5m depth + aisle
- 45° parking: 4.2m depth + aisle
- 60° parking: 4.8m depth + aisle
- 90° parking: 5.0m depth + aisle

On-Street vs. Off-Street Parking

On-Street Parking:

- Within public right-of-way
- Parallel to or angled from the carriageway
- Free or metered
- Convenient for short-term parking
- Reduces effective roadway width

Off-Street Parking:

- Dedicated parking lots or structures
- Removes parking from roadway
- More capacity
- Controlled access and payment

Design Considerations

Location:

- Should not obstruct through traffic flow
- Adequate sight distance at intersections (no parking near corners)
- Away from bus stops and driveways

Sight Distance:

- No parking within 15-30m of intersections
- Maintain visibility for crossing pedestrians

Access and Egress:

- Adequate maneuvering space
- Clear markings

Surface:

- Durable pavement (concrete or asphalt)
- Proper drainage to prevent ponding
- Marked stalls with paint

Drainage:

- Sloped toward drainage inlets
- 2% cross slope minimum

Enforcement:

- Clear signage indicating regulations
- Time limits, payment requirements
- Loading zones vs. general parking

7. Bus Bays

Definition

Bus bays are specially designed and designated areas where buses can stop to board and alight passengers without obstructing through traffic flow on the main carriageway.

Types of Bus Bays**1. Bus Lay-by (Off-Line Bus Bay):****Description:**

The bus completely exits the through traffic lane into a parallel bay, allowing traffic to pass unobstructed.

Design:

- Length: 12-15m for single bus, 24-30m for articulated bus or multiple buses
- Width: 3.0-3.5m

- Entry taper: 1:10 to 1:20 gradient
- Exit taper: 1:5 to 1:10 gradient (steeper for easier merging)
- Deceleration length: 20-40m before bay
- Acceleration length: 40-60m after bay

Advantages:

- Through traffic unaffected
- Better for high-speed roads
- Safer for passengers (no passing vehicles)

Disadvantages:

- Requires additional pavement width
- Bus may have difficulty merging back into traffic
- Higher construction cost

2. Bus Bulb (On-Line Bus Bay / Bus Bulb-Out):

Description:

The bus stops in the travel lane, but the footpath extends outward into what would be a parking lane, shortening pedestrian crossing distance and improving accessibility.

Design:

- Bus stops in travel lane
- Footpath bulges outward to bus
- Platform level with bus floor (200mm height)
- Length: 15-20m

Advantages:

- No re-merging issues for bus
- Shorter pedestrian crossing distance
- Emphasizes pedestrian priority
- Lower cost where parking lane exists
- Better for frequent-stop urban routes

Disadvantages:

- Obstructs through traffic while bus stopped

- Not suitable for high-speed roads
- Requires removal of parking spaces

Design Standards

Platform:

- Height: 150-200mm above road level (for low-floor buses)
- Height: 250-300mm (for standard buses)
- Width: 2.0-3.0m
- Surface: Non-slip, well-drained
- Tactile paving for visually impaired

Shelter:

- Weather protection for waiting passengers
- Seating for 4-8 persons
- Lighting for night visibility
- Transparent sides for security
- Advertisement space (revenue generation)

Location:

- Near-side of intersection (before crossing) or far-side (after crossing)
- Far-side preferred (buses don't block sight distance)
- Adequate sight distance in both directions
- Near pedestrian crossings (if possible)

Spacing:

- 400-800m in urban areas
- Closer spacing (300-500m) in dense areas
- Based on service frequency and demand

Signage and Markings:

- Bus stop sign and route information
- Pavement markings ("BUS ONLY")
- No parking signs in bay area

8. Frontage Roads (Service Roads)

Definition

Frontage roads, also called service roads or access roads, are local roads running parallel to a higher-classification road (such as an expressway or arterial highway) to provide access to adjacent properties without allowing direct access to the main road.

Purpose and Functions

Access Management:

Provides property access while preventing direct driveways onto high-speed main roads, improving safety and maintaining capacity.

Traffic Separation:

Separates slow-moving local traffic from fast-moving through traffic on the main road.

Reduces Conflicts:

Eliminates or greatly reduces conflict points (merging, weaving) on the main road.

Improves Safety:

Direct access to high-speed roads is hazardous; frontage roads provide safer low-speed access.

Maintains Capacity:

Prevents capacity loss on main road from turning and entering vehicles.

Future Expansion:

Facilitates future widening of main road without impacting access.

Design Features

Width:

- Typically 2-lane roads: 6.0-7.0m carriageway
- Single lane: 4.0-5.0m with passing places
- Urban areas: May include parking (8.0-10.0m total)

Design Speed:

- Lower than main road: 30-50 km/h
- Safe for residential/commercial access

Connection Points:

- Connected to main road at selected intersections (interchanges)
- Spacing: 1-3 km typically

- Grade-separated or signal-controlled

One-Way vs. Two-Way Operation:

One-Way Frontage Roads:

- Each side operates in same direction as adjacent main road lane
- Simpler intersection design at connection points
- Safer merging and diverging
- Common on expressways

Two-Way Frontage Roads:

- Both directions of travel on one or both sides
- Requires traffic signals or careful design at connections
- Provides better local circulation

Separation from Main Road:

- Barrier or median: 3-10m wide
- Landscaped buffer zone preferred
- May include drainage facilities
- Noise barrier if needed

Cross-Section Elements:

- Carriageway: 6-7m (2-lane)
- Shoulders or parking: 1.5-2.5m each side
- Footpaths in urban areas: 1.5-2.0m
- Drainage: Side drains or kerb and gutter

Drainage:

- Must not discharge onto main road
- Separate drainage system or connected at culverts
- Adequate capacity for local runoff

Utility Accommodation:

- Frontage roads often accommodate utilities
- Water, sewer, power, telecom lines
- Access manholes and service connections

Real-Life Examples in India

- **Mumbai-Pune Expressway:** Extensive frontage/ service roads along most sections
- **Delhi-Gurgaon Expressway (NH-48):** Service roads provide local access
- **Ahmedabad BRTS Corridor:** Service roads separate local from BRT traffic

9. Embankment and Cut Slopes

Definition

Embankment slopes are the inclined side surfaces of earth or rock fill constructed to raise the roadway above natural ground level. Cut slopes are the inclined excavated surfaces where the roadway has been excavated below natural ground level. Both require careful design for stability, drainage, and erosion control.

Embankment Slopes

Purpose:

- Raise road elevation to achieve desired gradient
- Bridge low-lying or flood-prone areas
- Provide adequate height for drainage
- Reduce grade changes and improve alignment

Design Considerations:

1. Side Slope Ratio:

The slope steepness depends on:

- Fill material properties (soil type, shear strength)
- Height of embankment
- Foundation conditions
- Availability of right-of-way
- Long-term stability requirements

Typical Slope Ratios (Horizontal:Vertical):

Fill Material	Embankment Height	Slope Ratio (H:V)
Good Quality Soil	< 3m	2:1
Good Quality Soil	3-6m	2:1 to 1.5:1

Good Quality Soil	> 6m	1.5:1 to 2:1 (flatter)
Weak/Poor Soil	Any height	2.5:1 to 3:1
Rock Fill	Any height	1:1 to 1.5:1

2. Foundation Preparation:

- Remove vegetation, topsoil, and organic matter
- Excavate weak foundation soil if necessary
- Provide adequate compaction of foundation
- Benching of sloped natural ground
- Install geotextiles if weak subgrade

3. Fill Material Selection:

- Free-draining granular materials preferred
- Avoid highly plastic clays
- No organic matter or perishable materials
- Adequate bearing capacity and shear strength

4. Compaction:

- Layered placement: 150-300mm loose thickness
- Moisture control: Near optimum moisture content
- Compaction: 95-98% Standard Proctor Density
- Increased compaction near pavement (100%)

5. Settlement:

- Immediate settlement during construction
- Consolidation settlement over time
- Account for settlement in design (over-fill)
- Monitoring of high embankments

6. Stability:

- Stability analysis for slopes (factor of safety ≥ 1.5)
- Slip circle analysis for cohesive soils
- Consider seepage, earthquakes, traffic loads
- Install toe drains if required

Slope Protection:

1. Vegetative Protection:

- Grass seeding or sodding on slopes
- Prevents surface erosion
- Aesthetic benefits
- Requires maintenance (mowing)
- Suitable for slopes $\leq 2:1$ and low embankments

2. Stone Pitching:

- Hand-placed stones on slope surface
- Stone size: 150-250mm
- Thickness: 150-300mm
- Prevents erosion in high-rainfall areas
- Used on steep slopes or near water

3. Riprap (Loose Stone):

- Larger stones (200-500mm)
- Placed on geotextile filter
- Used on very steep slopes or riverbanks
- Heavy-duty erosion protection

4. Retaining Walls:

- Where space doesn't permit flatter slopes
- Concrete or masonry walls
- Geotechnical design required
- Expensive but effective

5. Geosynthetic Reinforcement:

- Geogrid or geotextile layers within fill
- Allows steeper slopes
- Improves stability
- Modern engineered solution

Drainage:

Surface Drainage:

- Berms at intervals on long slopes (every 6-10m vertical)
- Collect runoff and direct to side drains
- Prevent erosion from concentrated flow

Subsurface Drainage:

- Toe drains at embankment base
- Relieve pore water pressure
- Improve stability
- Filter wrapped drains

Cut Slopes

Purpose:

- Lower road elevation where natural ground is high
- Achieve desired gradient through hills
- Improve alignment and reduce grades
- Access areas below surrounding terrain

Design Considerations:

1. Slope Ratio:

Depends on material being excavated:

Material Type	Typical Slope Ratio (H:V)	Remarks
Hard Rock	0.25:1 to 0.5:1 (vertical to steep)	Very stable
Weathered Rock	0.5:1 to 1:1	Depends on weathering degree
Stiff Clay	1:1 to 1.5:1	Stability analysis required
Sandy Soil	1.5:1 to 2:1	Depends on cohesion
Loose Soil/Gravel	2:1 to 3:1 (flatter)	More prone to failure

2. Geological Conditions:

- Rock type and structure (bedding, joints, faults)

- Weathering degree and rate
- Groundwater seepage
- Potential for landslides or rockfalls
- Historical performance of nearby cuts

3. Groundwater Control:

Critical for cut slope stability:

- Groundwater increases weight and reduces strength
- Seepage creates erosion and piping
- Freeze-thaw damage in cold climates

Drainage Measures:

Hillside (Catch-Water) Drains:

- Located at top of cut slope
- Intercepts surface runoff from upslope areas
- Prevents water from flowing down cut face
- Lined with masonry or concrete
- Adequate capacity for design storm

Weep Holes:

- Drilled horizontally into cut slope face
- Allows groundwater to drain out
- Reduces pore pressure
- Typically 75-100mm diameter
- Spaced 2-3m apart

French Drains/Drainage Galleries:

- Subsurface drains behind cut slope
- Gravel-filled trenches with perforated pipe
- Lowers groundwater table
- Prevents slope failure

Benches:

- Horizontal steps on tall cut slopes

- Break slope into smaller sections
- Collect and drain surface runoff
- Provide access for maintenance
- Typically 3-5m width every 6-10m vertical

Slope Protection:

1. Rock Bolts and Anchors:

- Steel bolts grouted into rock face
- Prevents rockfall and stabilizes loose blocks
- Used on fractured rock slopes
- Professional geotechnical design required

2. Shotcrete (Sprayed Concrete):

- Concrete sprayed onto rock/soil face
- Prevents weathering and erosion
- Can be reinforced with mesh
- Suitable for steep slopes

3. Wire Mesh and Netting:

- Prevents loose rocks from falling onto roadway
- Draped over slope or anchored
- Low-cost protective measure
- Doesn't prevent slope failure, only catches material

4. Rock Sheds and Tunnels:

- Concrete structures over roadway
- Protects from rockfall and avalanches
- Expensive but necessary in extreme hazard areas
- Common in mountainous terrain

5. Vegetation:

- Grass, shrubs, trees on soil slopes
- Roots bind soil and prevent erosion
- More difficult to establish on cuts than fills

- May require soil amendment or hydroseeding

Safety Considerations:

Rockfall Protection:

- Catch ditches at toe of slope: 1.5-3.0m wide, 1.0m deep
- Barrier fences where catch ditch insufficient
- Warning signs in rockfall zones

Sight Distance:

- Clear vegetation on inside of curves
- Excavate/flatten slopes where restricting sight distance
- Critical for safety

Maintenance Access:

- Benches provide access for inspection and repairs
- Safe access to slope face for workers

Right of Way (ROW) / Width of Formation

Definition

Right of Way (ROW), also called land width or width of formation, is the total width of land acquired by the highway authority for constructing and maintaining the road, including all its elements. It extends from boundary to boundary and encompasses the carriageway, shoulders, side slopes (cut/fill), drains, safety clear zones, utilities, and allowance for future expansion. The ROW ensures sufficient space for the highway to function safely and efficiently while providing legal protection against encroachment. It varies based on road classification, terrain, and development context, and represents a permanent land acquisition for public transportation purposes.

Explanation (8 key points)

1. ROW width encompasses all physical road elements plus future expansion needs.
2. It provides legal authority for highway construction, operation, and maintenance.
3. Width requirements vary by road classification, with National Highways requiring maximum ROW.
4. Terrain significantly affects ROW due to varying cut/fill slope requirements.

5. Urban areas often require wider ROW to accommodate utilities and development interfaces.
6. Adequate ROW prevents encroachment and facilitates safe maintenance operations.
7. Land acquisition is a complex legal process with compensation paid to landowners.
8. Insufficient ROW leads to safety issues, maintenance difficulties, and future widening problems.

Components within Right of Way

For a typical 2-lane National Highway with 30m ROW:

1. **Carriageway:** 7.0m (2 lanes × 3.5m)
2. **Paved Shoulders:** 3.0m (1.5m × 2 sides)
3. **Granular Shoulders/Earthen:** 5.0m (2.5m × 2 sides)
4. **Side Drains:** 2.0m (1.0m × 2 sides)
5. **Cut/Fill Slopes:** Variable depending on height
6. **Clear Zone:** 3-5m for safety
7. **Utility Corridor:** Space for power lines, telecom, water/sewer
8. **Future Expansion:** Reserve width for adding lanes

Factors Affecting Right of Way

1. Road Classification and Function:

Higher classification roads require wider ROW:

- **National Highways:** Serve inter-state traffic, higher speeds, multiple lanes, extensive facilities
- **State Highways:** State-level connectivity, moderate volumes
- **District Roads:** Local connectivity, lower volumes and speeds
- **Village Roads:** Minimal facilities, narrow ROW sufficient

2. Number of Lanes and Traffic Volume:

- Current traffic volume determines initial lane requirements
- 20-30 year traffic projections guide ultimate ROW needs
- Multi-lane facilities require proportionally wider ROW
- High-volume roads need additional lanes, wider shoulders, more utilities

3. Design Speed:

Higher design speeds require:

- Wider lanes (3.5m vs. 3.0m)
- Wider shoulders for emergency stopping
- Gentler curves requiring more land on curve outsides
- Greater clear zones free of hazards

4. Terrain and Topography:

Plain Terrain:

- Standard ROW widths applicable
- Minimal cut/fill slopes
- Predictable and uniform ROW

Rolling Terrain:

- Moderate cuts and fills
- Side slopes require additional width
- ROW varies along alignment
- 20-30% more than plain terrain

Mountainous/Hilly Terrain:

- Extensive cutting and filling required
- Side slopes can consume significant width
- Cut slopes: 1:1 to 1.5:1 (may be steeper in rock)
- Fill slopes: 1.5:1 to 2:1
- ROW can be 50-100% more than plain terrain
- May require retaining walls to limit ROW

Example:

A 6m high embankment with 2:1 slopes requires 12m horizontal distance on each side just for the slope, plus the standard road elements.

5. Drainage Requirements:

- Arid/low rainfall areas: Minimal drainage facilities
- High rainfall areas: Substantial side drains, culverts, subsurface drainage
- Flood-prone areas: Elevated embankments with extensive drainage

- Drainage elements can add 2-5m to each side of ROW

6. Development Potential and Land Use:

Urban/Suburban Areas:

- Higher land values but greater need for wide ROW
- Utilities (water, sewer, power, telecom, gas) require significant space
- Footpaths, cycle tracks, street trees, lighting
- On-street parking lanes
- Frequent property access (driveways)
- Underground utilities need maintenance access
- Future development pressures
- May require 50-100% more ROW than rural equivalent

Rural/Agricultural Areas:

- Lower development density
- Fewer utilities
- Standard agricultural ROW sufficient
- Lower land acquisition costs allow adequate ROW

Industrial Corridors:

- Heavy vehicle access requirements
- Possible future industrial siding needs
- Utility corridors for industrial services
- Freight transfer facilities

7. Utility Requirements:

Modern highways must accommodate numerous utilities:

- **Overhead:** High-voltage power lines, streetlights
- **Underground:** Water supply, sewerage, storm drains, telecom cables, gas pipelines, fiber optic networks
- Each utility requires horizontal and vertical clearances
- Maintenance access required without disrupting traffic
- Shared utility corridors becoming standard

- Typically adds 3-10m to urban ROW

8. Environmental and Safety Considerations:

Clear Zone:

- Area free of rigid hazards (trees, poles, steep slopes)
- Allows errant vehicles to recover safely
- Width depends on design speed and traffic volume
- Typically 3-10m from edge of traveled way

Buffer Zones:

- Environmental protection areas (wetlands, forests)
- Noise barriers and visual screening
- Wildlife crossing corridors
- Green belts and landscaping

9. Economic Factors:

Land Acquisition Costs:

- Major component of project cost, especially in urban areas
- Must balance adequate ROW with project affordability
- Cost-benefit analysis: Wider ROW upfront vs. future widening costs
- Prime urban land may be prohibitively expensive

Compensation:

- Market value of land
- Structures and crops
- Loss of income/business
- Resettlement costs
- Can be 20-50% of total project cost

Long-term Savings:

- Adequate ROW avoids future widening costs and disruptions
- Easier maintenance with sufficient working room
- Reduced accident costs with proper clear zones

10. Legal and Administrative:

Land Acquisition Laws:

- Right to Fair Compensation and Transparency in Land Acquisition, Rehabilitation and Resettlement Act, 2013 (India)
- Social Impact Assessment required
- Consent requirements
- Rehabilitation and resettlement planning

State Policies:

- Each state may have additional ROW requirements
- Variations in acquisition procedures
- Political and social acceptance

Survey and Documentation:

- Accurate surveys of affected properties
- Title searches and ownership verification
- Public hearing and objection process
- Time-consuming administrative procedures

IRC Recommendations for Right of Way (Detailed)

Rural Areas (Plain and Rolling Terrain):

Road Classification	No. of Lanes	Min ROW (m)	Desirable ROW (m)	Remarks
National Highway (Expressway)	4-8	60	80-100	Service roads may require more
National Highway	4	45	60	With paved shoulders
National Highway	2	24	30	Standard 2-lane
State Highway	2	20	24	May match NH in high-traffic corridors
Major District Road (MDR)	2	15	20	

Other District Road (ODR)	Intermediate/2	12	15	
Village Road (VR)	Single lane	9	12	With passing places

Rural Areas (Mountainous and Hilly Terrain):

Road Classification	Min ROW (m)	Desirable ROW (m)	Remarks
National Highway	50-60	80-100	Extensive cut/fill slopes
State Highway	30-40	45-60	Varies with terrain severity
Major District Road	20-30	30-40	
Other District Road	15-20	20-30	
Village Road	12-15	15-20	

Note: Actual ROW in mountains varies significantly based on specific site conditions. Sections with retaining walls may have narrower ROW, while sections with natural slopes may require much wider ROW.

Urban Areas:

Road Classification	Min ROW (m)	Desirable ROW (m)	Typical Elements
Urban Expressway/Arterial (6-8 lane)	60	80-100	Service roads, footpaths, utilities, medians
Urban Arterial (4-6 lane)	40-45	60-80	Parking, footpaths, cycle tracks, utilities
Sub-Arterial (4 lane)	30	40-50	Footpaths, parking, utilities
Collector Street (2-4 lane)	18-24	30	Footpaths, limited parking
Local Street (2 lane)	12-15	18-24	Footpaths, residential access

Urban areas have higher land costs but greater need for wide ROW due to:

- Extensive utility networks

- Pedestrian and cyclist facilities
- On-street parking demands
- Tree planting and landscaping
- Future expansion needs

Breakdown of ROW Allocation (Example)

2-Lane National Highway - 30m ROW (Rural Plain Terrain):

text

Total ROW: 30.0m

Breakdown:

- Carriageway ($2 \times 3.5\text{m}$): 7.0m
- Paved shoulders ($2 \times 1.5\text{m}$): 3.0m
- Earthen shoulders ($2 \times 2.5\text{m}$): 5.0m
- Side drains ($2 \times 1.0\text{m}$): 2.0m
- Safety clear zone and slopes: 10.0m
- Utility and expansion reserve: 3.0m

4-Lane National Highway - 60m ROW (Rural):

text

Total ROW: 60.0m

Breakdown:

- Dual carriageways ($2 \times 7.0\text{m}$): 14.0m
- Median: 5.0m
- Paved shoulders ($4 \times 3.0\text{m}$): 12.0m
- Earthen shoulders/drains ($4 \times 2.5\text{m}$): 10.0m
- Side drains: 2.0m
- Safety zones, slopes, utilities: 17.0m

Urban Arterial - 45m ROW:

text

Total ROW: 45.0m

Breakdown:

- Carriageway (4 lanes \times 3.5m): 14.0m
- Median: 3.0m
- Parking lanes (2 \times 2.5m): 5.0m
- Footpaths (2 \times 3.0m): 6.0m
- Service roads (2 \times 6.0m): 12.0m (optional)
- Utility corridors: 5.0m

Land Acquisition Process (Detailed)

Step 1: Planning and Survey (6-12 months)

- Route alignment finalization
- Detailed topographic and cadastral surveys
- Identification of affected land parcels and owners
- Estimation of land area requirements
- Preliminary cost estimates

Step 2: Social Impact Assessment (3-6 months)

- Required under 2013 Land Acquisition Act
- Assessment of impact on affected families
- Public consultation and information dissemination
- Identification of vulnerable groups
- Resettlement and rehabilitation planning

Step 3: Preliminary Notification (Public Notice)

- Intent to acquire land published in official gazette and local newspapers
- Posted in affected villages/areas
- Allows public to inspect plans and raise objections
- Objections heard by competent authority

- Timeline: 60 days for objections

Step 4: Declaration and Award (6-12 months)

- Declaration of intent to acquire for public purpose
- Detailed measurement and assessment of each parcel
- Assessment of compensation based on:
 - Market value of land
 - Solatium (additional compensation): 100% of market value
 - Structures, trees, crops
 - Loss of livelihood and business
- Award announced specifying compensation amounts
- Timeline: Award within 12 months of declaration

Step 5: Compensation Payment and Possession

- Compensation deposited with land owners
- Disputes go to arbitration or court
- Physical possession taken after compensation payment
- Handover to executing agency
- Timeline: Variable, can extend years if disputes arise

Step 6: Resettlement and Rehabilitation (Ongoing)

- Provision of alternative housing if residential land acquired
- Employment assistance
- Infrastructure in resettlement areas
- Monitoring of rehabilitation progress

Challenges:

- Multiple ownership and title disputes
- Objections and litigation (can delay projects for years)
- Compensation disputes
- Encroachments on government land
- Political and social resistance
- Insufficient funds for prompt compensation

Types of Sight Distance

Definition

Sight distance is the length of roadway ahead visible to a driver, measured from the driver's eyes to an object on the roadway. It is fundamental to highway geometric design, ensuring drivers have adequate time to perceive, react to, and safely respond to hazards, other vehicles, pedestrians, and geometric features. The required sight distance depends on the driving task (stopping, overtaking, intersection crossing), design speed, vehicle characteristics, driver perception-reaction time, and roadway conditions. Five main types address different operational scenarios: Stopping Sight Distance (SSD), Overtaking Sight Distance (OSD), Sight Distance at Intersections, Intermediate Sight Distance (ISD), and Headlight Sight Distance (HSD).

Explanation (8 key points)

1. Sight distance directly affects road safety and operational efficiency.
2. It depends on driver eye height, object height, and roadway geometry.
3. Horizontal and vertical curves can severely restrict available sight distance.
4. Design speed is the primary determinant of required sight distance.
5. SSD must be continuously available along entire road length.
6. OSD is required periodically on two-lane roads for safe overtaking.
7. Nighttime sight distance may be limited by headlight beam length and direction.
8. Adequate sight distance reduces accidents and improves traffic flow.

Standard Assumptions

Driver Eye Height:

- Passenger cars: 1.2m above road surface
- Trucks/buses: 2.0-2.4m

Object Height:

- SSD: 0.15m (represents tail lights of stopped vehicle)
- ISD: 0.15m
- OSD: 1.2m (driver's eye height in oncoming vehicle)
- HSD: 0.15m (object on roadway)

Perception-Reaction Time:

- Standard: 2.5 seconds (includes perception, decision, and reaction initiation)
- Complex situations: 3-4 seconds

Coefficient of Friction (f):

- Dry pavement: 0.35-0.40
- Wet pavement: 0.30-0.35 (design value to account for worst case)
- Design typically uses 0.35-0.37

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