

# Module 3

**Importance of Transportation,** Transportation modes i.e. Highway, railway, airways, water, pipe and conveyor – Basic Characteristics, advantages and disadvantages.

**Indian road transport system:** Types of roads, classification of highway, urban roads: basic requirements and classification.

Basic Components of a Road, Rigid and Flexible Pavement (comparison only)

## Transportation engineering

- Transportation engineering is a branch of civil engineering focused on the planning, design, operation, and management of transportation systems.
- It deals with the safe and efficient movement of people and goods by various modes, including roads, railways, airways, waterways, and pipelines.
- The field aims to optimize transport infrastructure to meet societal needs, improve safety, and promote sustainability.



# Importance of Transportation

Transportation plays a crucial role in basic civil engineering for several reasons:

- 1. Accessibility and Connectivity:** Transportation systems, such as roads, highways, bridges, and railways, provide the necessary infrastructure for connecting different regions, cities, and communities. This connectivity is essential for economic development and social integration.
- 2. Economic Growth:** Efficient transportation networks facilitate the movement of goods and people, which is vital for economic growth. They enable the distribution of goods to markets, access to resources, and the functioning of supply chains, thereby contributing to economic development.
- 3. Urban Planning and Development:** In urban and regional planning, transportation infrastructure is a fundamental consideration. Proper transportation planning can influence land use, population distribution, and the development of residential, commercial, and industrial areas.
- 4. Safety:** Designing safe transportation systems is a paramount concern in civil engineering. Roads, bridges, tunnels, and other transportation infrastructure must be built and maintained to high safety standards to reduce the risk of accidents and ensure the well-being of travelers.

**5. Environmental Impact:** Transportation can have significant environmental impacts, including air pollution, noise pollution, and habitat disruption. Civil engineers play a role in designing and implementing transportation solutions that minimize these negative effects, such as through the development of eco-friendly transportation options like public transit and sustainable roadway design.

**6. Sustainability:** Sustainable transportation practices, such as the use of public transportation, carpooling, cycling, and walking, are important in reducing energy consumption, emissions, and traffic congestion. Civil engineers can promote and design these sustainable transportation solutions.

**7. Efficiency and Congestion Relief:** Effective transportation systems aim to reduce congestion, enhance travel time efficiency, and improve overall system performance. Civil engineers design and implement measures to achieve these goals, such as intelligent transportation systems, traffic management strategies, and the expansion or optimization of transportation infrastructure.

**8. Resilience and Disaster Preparedness:** Transportation infrastructure must be designed to withstand natural disasters and other emergencies. Civil engineers consider factors like seismic activity, flooding, and extreme weather when designing transportation facilities to ensure their resilience and the continuity of essential services.

**9. Accessibility for All:** Civil engineers work to create transportation systems that are accessible to people with disabilities, the elderly, and all members of the community. This involves designing infrastructure with features like ramps, elevators, and tactile pavements to ensure inclusivity.

**10. Innovation and Technology:** Advances in transportation technology, such as autonomous vehicles, electric vehicles, and high-speed rail, require the expertise of civil engineers to develop and integrate these innovations into existing transportation systems.

## Transportation Modes

The various transportation modes are as follows:

1. Roadways
2. Railways
3. Airways
4. Waterways
5. Pipe ways
6. Conveyor

### Roadways/Highways

Highways are a type of road designed for high-speed vehicular traffic and long-distance travel. They have specific characteristics, advantages, and disadvantages that make them a critical component of transportation networks.

#### Characteristics of Highways:

1. **High-Speed Limits:** Highways are designed for higher speeds, typically with posted speed limits ranging from 88 km/h to 120 km/h or more, depending on the region and country.
2. **Limited Access:** Highways often have limited access points, such as entrance and exit ramps, to control traffic flow and reduce the potential for congestion.
3. **Multiple Lanes:** Highways generally consist of multiple lanes in each direction, allowing for the safe passing of vehicles and facilitating a smoother traffic flow.
4. **Divided Roadways:** Many highways feature divided roadways, with a median or barrier separating opposing traffic, enhancing safety.
5. **Controlled Intersections:** Intersections on highways are typically controlled with traffic lights or interchanges to minimize the risk of collisions.
6. **Designed for Long Distances:** Highways are designed for long-distance travel, making them ideal for regional and national transportation.

Advantages of Highways:	Disadvantages of Highways:
<p>1. <b>Efficiency:</b> Highways provide a fast and efficient means of travel, reducing travel times for long distances and facilitating the movement of goods and people.</p> <p>2. <b>Safety:</b> With controlled access points, divided roadways, and often fewer intersections, highways tend to have lower accident rates compared to other road types.</p> <p>3. <b>Reliability:</b> Highways are generally well-maintained and equipped with safety features, which enhances reliability for travelers.</p> <p>4. <b>Economic Impact:</b> Highways are critical for commerce and the economy, as they facilitate the transportation of goods, boosting trade and economic development.</p> <p>5. <b>Accessibility:</b> Highways provide access to various destinations, including urban centers, suburban, and rural areas, promoting accessibility to jobs, education, healthcare, and leisure activities.</p> <p>6. <b>Reduced Congestion:</b> Well-designed highways can help reduce traffic congestion by offering alternative routes to crowded city streets.</p>	<p>1. <b>Environmental Impact:</b> Highways can have a significant environmental impact, leading to air and noise pollution, habitat disruption, and the destruction of natural landscapes.</p> <p>2. <b>High Costs:</b> Building and maintaining highways can be expensive, and the financial burden often falls on governments or taxpayers.</p> <p>3. <b>Land Use Changes:</b> Highway construction can result in changes to land use patterns, such as urban sprawl, which can have negative consequences on communities and the environment.</p> <p>4. <b>Limited Accessibility:</b> The limited access points on highways may require people to travel longer distances to access the road, which can be inconvenient in some cases.</p> <p>5. <b>Safety Concerns:</b> Although highways are generally safer than other roads, they can still experience high-speed accidents and are often associated with a higher fatality rate when accidents do occur.</p> <p>6. <b>Maintenance Challenges:</b> Highways require regular maintenance to ensure safety and functionality. Neglecting maintenance can lead to deteriorating road conditions.</p> <p>7. <b>Congestion:</b> Highways, especially in urban areas, can still experience congestion during peak travel times, which may negate some of the advantages of fast travel.</p>

# Railways

Railways are a mode of transportation that involves trains running on dedicated tracks or rail lines. They have distinct characteristics, advantages, and disadvantages that make them an important part of transportation systems.

Characteristics of Railways:

1. **Dedicated Tracks:** Trains run on dedicated tracks, which are often separated from roadways, ensuring safety and preventing conflicts with other traffic. The speed of railways ranges from 150 km/h to 200 km/h.
2. **Steel Wheels on Steel Rails:** Trains use steel wheels on steel rails, providing low rolling resistance, which allows for efficient movement of heavy loads.
3. **Fixed Routes:** Railways have fixed routes and predefined schedules, which can enhance predictability and reliability for passengers and shippers.
4. **Electric or Diesel Locomotives:** Trains are typically powered by electric or diesel locomotives, which can vary in size and power to accommodate different loads and terrains.
5. **Capacity for weight:** Railways are well-suited for transporting bulk and heavy weight, such as coal, oil, and manufactured goods.
6. **Passenger Services:** Railways offer passenger services for both short-distance commuter travel and long-distance intercity travel.

**Advantages of Railways:**

- 1. **Efficiency:** Railways are known for their energy efficiency and ability to move large quantities of goods and people with relatively low energy consumption per ton-mile or passenger mile.
- 2. **Environmental Benefits:** Trains produce fewer greenhouse gas emissions and air pollution per unit of cargo or passenger transported compared to many other modes of transportation.
- 3. **Safety:** Railways are among the safest modes of transportation, with lower accident rates and fewer fatalities compared to road transportation.
- 4. **Capacity:** Railways have a high capacity for moving bulk cargo over long distances, making them suitable for industries such as agriculture, mining, and manufacturing.
- 5. **Predictability:** Railways often run on fixed schedules, which can offer reliability for both passenger and freight services.
- 6. **Reduced Traffic Congestion:** By moving goods via rail, especially over long distances, railways help alleviate road congestion, reducing wear and tear on road infrastructure.
- 7. **Economies of Scale:** Railways benefit from economies of scale, as larger trains can be more efficient in terms of fuel consumption and labour costs per unit of cargo.

**Disadvantages of Railways:**

- 1. **Limited Flexibility:** Railways are constrained by fixed routes and schedules, which may not be as flexible as road transportation for reaching specific destinations.
- 2. **Infrastructure Costs:** Building and maintaining rail infrastructure can be expensive, requiring significant investments in tracks, signals, and bridges.
- 3. **Service Frequency:** Some rail services may have lower frequencies than road transportation, which could be less convenient for passengers or shippers needing more frequent service.
- 4. **First/Last Mile Challenges:** Railways often require efficient transportation to and from railway stations (the "first mile" and "last mile"), which can be a logistical challenge.
- 5. **Technology and Speed:** In some cases, rail transportation may be slower than other modes, such as air or truck transport, especially for long distances or time-sensitive shipments.
- 6. **Accessibility:** Rail stations may not be as accessible as road infrastructure, making it difficult for passengers or shippers to reach them easily.



## Airways

Airways, which refer to the mode of transportation involving aero planes, have unique characteristics, advantages, and disadvantages that make them an essential part of modern transportation systems.

### Characteristics of Airways:

- 1. Aerial Travel:** Airways involve the movement of passengers and cargo through the air using aero planes.
- 2. Airports:** Air travel typically originates and terminates at airports, which serve as hubs for passenger check-in, security screening, and boarding.
- 3. Wide Range of Aircraft:** Airways encompass a variety of aircraft, including small regional planes, commercial airliners, cargo planes, and private jets, each designed for specific purposes.
- 4. Global Connectivity:** Air travel offers fast and efficient connections between cities and countries, enabling global connectivity.
- 5. Long-Distance Travel:** Air travel is particularly efficient for long-distance and intercontinental journeys.

**Advantages of Airways:**

**1. Speed and Efficiency:** Airways are the fastest mode of long-distance transportation, allowing passengers and goods to reach distant destinations quickly.

**2. Global Connectivity:** Air travel offers access to virtually any location on Earth, making it essential for international business, tourism, and emergency response.

**3. Safety:** Commercial air travel is one of the safest modes of transportation, with rigorous safety regulations and well-trained crews.

**4. Time Savings:** Air travel reduces travel times significantly compared to other modes, making it suitable for time-sensitive passengers and cargo.

**5. Reliability:** Air travel is less susceptible to weather-related disruptions compared to modes like road or maritime transport.

**6. Cargo Transportation:** Air cargo services transport valuable and time-sensitive goods, such as electronics and medical supplies, rapidly around the world.

**Disadvantages of Airways:**

**1. Environmental Impact:** Air travel contributes to greenhouse gas emissions, making it a source of concern for climate change. Emissions per passenger mile are generally higher compared to other modes.

**2. High Costs:** Air travel can be expensive, both for passengers and for cargo shipping, particularly for long-haul flights.

**3. Airport Congestion:** Major airports in urban areas can experience congestion, leading to delays, increased travel times, and operational challenges.

**4. Security Concerns:** Security measures and regulations can be time-consuming and can lead to passenger inconveniences.

**5. Limited Accessibility:** Airports may not be easily accessible from some areas, requiring additional transportation for passengers to reach their destinations.

**6. Weather Dependency:** Flights can be delayed or cancelled due to adverse weather conditions, impacting travel plans.

**7. Luggage and Cargo Restrictions:** Weight and size restrictions on luggage and cargo can limit what passengers and shippers can transport.

**8. Noise Pollution:** Aircraft noise can affect communities around airports, leading to noise pollution concerns.

## 4. WATER WAYS

The basic characteristics of waterway transportation include:

- 1. High Capacity for Bulk Cargo:** Waterways are well-suited for transporting large quantities of heavy and bulky goods, such as coal, oil, grains, and industrial equipment, making them ideal for shipping bulk items over long distances.
- 2. Cost-Effective for Long Distances:** Water transport has low per-ton-mile costs compared to other modes, making it highly economical for long-distance and international trade, especially for non-urgent cargo.
- 3. Energy Efficiency and Environmental Friendliness:** Ships consume less fuel per ton mile than road or air transport, resulting in lower carbon emissions. This makes waterways a more sustainable option, especially for large shipments.
- 4. Global Reach and International Trade:** Waterways facilitate global trade, connecting ports across countries and continents. This connectivity is essential for importing and exporting goods worldwide.
- 5. Slow Speed:** Water transport is slower than air, rail, or road transport, making it less suitable for time-sensitive goods. Travel times can be affected by factors like weather, tides, and ocean currents.
- 6. Dependence on Ports and Waterways:** Ships and barges are limited to navigable waterways, such as rivers, canals, and oceans, and require port infrastructure for loading, unloading, and customs clearance.
- 7. Weather Dependency:** Waterway transportation is affected by weather conditions, including storms, rough seas, and icy waters, which can lead to delays and potential safety concerns.

<b>Advantages of Waterways:</b> <b>1. Cost-Effective:</b> Water transportation is often more cost-effective for bulk goods over long distances, as it can carry large quantities of cargo. <b>2. Energy Efficiency:</b> Water vessels are energy-efficient, requiring less fuel per ton-mile compared to other modes of transport. <b>3. Reduced Congestion:</b> Waterways are generally less congested than roadways, reducing the risk of traffic jams and delays. <b>4. Environmental Benefits:</b> Water transportation produces lower emissions per unit of cargo compared to road and air transportation, reducing its environmental impact. <b>5. Accessibility to Inland Areas:</b> Waterways can provide access to landlocked areas and facilitate trade to and from such regions. <b>6. Reliability:</b> Waterways offer reliable transport services, with predictable and steady shipping schedules.	<b>Disadvantages of Waterways:</b> <b>1. Limited Accessibility:</b> Waterways are not accessible to all regions, and goods may require additional overland transportation to reach their final destination. <b>2. Weather Dependency:</b> Adverse weather conditions, such as storms, can disrupt water transportation and cause delays. <b>3. Infrastructure Costs:</b> Dredging, maintaining locks, and ensuring channel depth can be expensive and may require ongoing investment. <b>4. Lack of Speed:</b> Water transportation is slower than road and air travel, making it less suitable for time-sensitive cargo. <b>5. Competition with Other Modes:</b> Water transportation must compete with road and rail for business, particularly for goods with tight delivery schedules. <b>6. Environmental Impact:</b> While water transportation is generally more eco-friendly, there can be concerns about water pollution and invasive species introduction. <b>7. Safety Issues:</b> Water travel can be associated with safety risks such as shipwrecks, collisions, and environmental incidents like oil spills.
---	--

## **Pipeline Transports**

Pipelines are a mode of transportation that involves the movement of liquids and gases through specialized pipelines or tubes. Below are the characteristics, advantages, and disadvantages of pipeline transportation:

### **Characteristics of Pipeline Transportation:**

- 1. Dedicated Infrastructure:** Pipelines consist of dedicated underground or above-ground infrastructure that can extend over long distances.
- 2. Types of Cargo:** Pipelines are used to transport various substances, including crude oil, natural gas, water, chemicals, and refined products.
- 3. Continuous Flow:** Once in operation, pipelines provide a continuous and uninterrupted flow of the transported substance.
- 4. Low Surface Impact:** Underground pipelines are hidden from view, minimizing their impact on the surface environment.
- 5. Reduced Environmental Exposure:** Pipelines can reduce the environmental exposure of hazardous or sensitive materials, as they are enclosed and leakages are often easier to detect and control.

**Advantages of Pipeline Transportation:**

- 1. Efficiency:** Pipelines are energy-efficient and can transport large quantities of liquids or gases over long distances with minimal energy consumption.
- 2. Low Operating Costs:** Once installed, pipelines tend to have lower operating and maintenance costs compared to other transportation modes.
- 3. Reduced Emissions:** Pipelines produce fewer greenhouse gas emissions and air pollutants per unit of cargo transported, making them a more environmentally friendly option.
- 4. Safety:** Pipelines are among the safest modes of transporting hazardous materials, with a low accident rate and reduced risk of human error.
- 5. Reliability:** Pipelines offer reliable transport services with consistent and predictable delivery schedules.
- 6. Reduced Congestion:** Pipelines do not contribute to road or rail congestion, which can be advantageous in high-traffic areas.

**Disadvantages of Pipeline Transportation:**

- 1. Initial Construction Costs:** Building pipelines can be expensive, especially over long distances, and can require significant upfront investment.
- 2. Limited Flexibility:** Pipelines are not easily adaptable to changing transportation needs, and they require extensive planning and investment for reconfiguration.
- 3. Environmental Impact During Construction:** Pipeline construction can disrupt local ecosystems and require the clearing of land, which may lead to habitat destruction.
- 4. Limited Accessibility:** Pipelines may not be accessible to all areas, and goods may require additional overland transportation to reach their final destination.
- 5. Risk of Leaks:** Although pipelines are generally safe, the risk of leaks or spills does exist, and the detection and repair of leaks can be challenging.
- 6. Resistance and Opposition:** The construction of new pipelines may face public and environmental opposition due to concerns about potential leaks, land use, and environmental impact.
- 7. Security Concerns:** Pipelines can be vulnerable to sabotage or terrorist attacks, necessitating security measures and monitoring.

## Conveyor Transport

Conveyor transportation is a system that involves the movement of materials, products, or goods using conveyor belts, chains, or rollers. It is commonly used in various industries, including manufacturing, warehousing, and distribution. Here are the characteristics, advantages, and disadvantages of conveyor transportation.

Characteristics of Conveyor Transportation:

- 1. Mechanical System:** Conveyor transportation relies on mechanical systems that move materials or products from one point to another. These systems can be simple, like roller conveyors, or complex, like automated conveyor systems used in manufacturing.
- 2. Continuous Movement:** Conveyors provide a continuous and controlled flow of materials, allowing for consistent and efficient transport
- 3. Diverse Applications:** Conveyor systems are versatile and can be customized for various purposes, such as material handling, assembly, packaging, and baggage handling at airports.
- 4. Variety of Conveyor Types:** Different types of conveyors are used, including belt conveyors, roller conveyors, screw conveyors, and overhead conveyors, each suited to specific applications.
- 5. Automation Capabilities:** Conveyor systems can be fully or partially automated, incorporating sensors, control systems, and sorting mechanisms for improved efficiency.
- 6. Modularity:** Conveyor systems are often designed with modular components, making it easier to expand or modify them to accommodate changing needs.

<b>Advantages of Conveyor Transportation:</b> <b>1. Efficiency:</b> Conveyors can transport materials and products at a consistent and high rate, reducing the need for manual labour and speeding up production or distribution processes. <b>2. Labor Savings:</b> Automated conveyor systems reduce the reliance on manual labour, which can lead to cost savings and reduced workplace injuries. <b>3. Space Utilization:</b> Conveyors can be configured to utilize available space efficiently, making them suitable for crowded or compact work areas. <b>4. Precise Movement:</b> Conveyor systems can be programmed to move materials with precision and accuracy, minimizing errors and improving quality control. <b>5. Reduced Material Handling:</b> Conveyors minimize the need for workers to move or carry heavy materials, reducing physical strain and the risk of injuries. <b>6. Continuous Operation:</b> Conveyors can operate continuously, 24/7 if needed, allowing for uninterrupted production or distribution. <b>7. Versatility:</b> Conveyor systems can handle a wide range of products, from small and lightweight items to heavy and bulk materials.	<b>Disadvantages of Conveyor Transportation:</b> <b>1. Initial Cost:</b> Setting up conveyor systems can be expensive, including the purchase and installation of equipment and associated control systems. <b>2. Maintenance:</b> Conveyor systems require regular maintenance to ensure proper functioning. Components like belts, rollers, and motors may need periodic replacement or repair. <b>3. Inflexibility:</b> Conveyor systems are not easily adaptable to changing production needs without significant modifications, which can be time-consuming and costly. <b>4. Energy Consumption:</b> Conveyor systems may consume a considerable amount of energy, especially in larger facilities. <b>5. Space Requirements:</b> Conveyor systems can be space-intensive, which may not be suitable for smaller or tightly packed work areas. <b>6. Material Limitations:</b> Some delicate or irregularly shaped materials may not be well-suited for conveyor transport, as they could be damaged or cause jams in the system. <b>7. Initial Setup Time:</b> Installing a conveyor system can be time-consuming, which may disrupt ongoing operations.
---	--



## **Pavement**

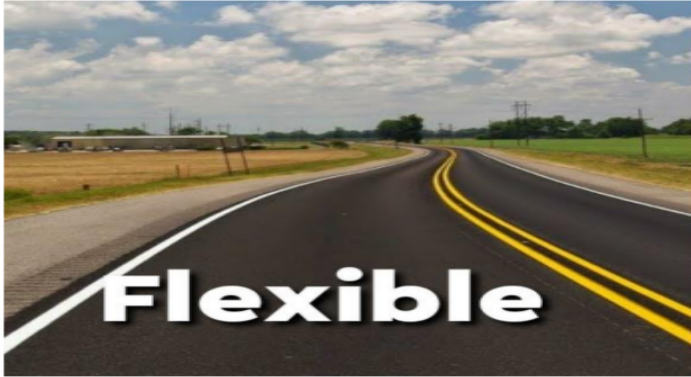
Pavement refers to a layered structure above the subgrade and below the wearing surface. Its main objective is to facilitate the transfer of loads from the moving vehicles to the subgrade and the soil underneath the subgrade.

As per the design considerations, types of pavement are

- Flexible pavement

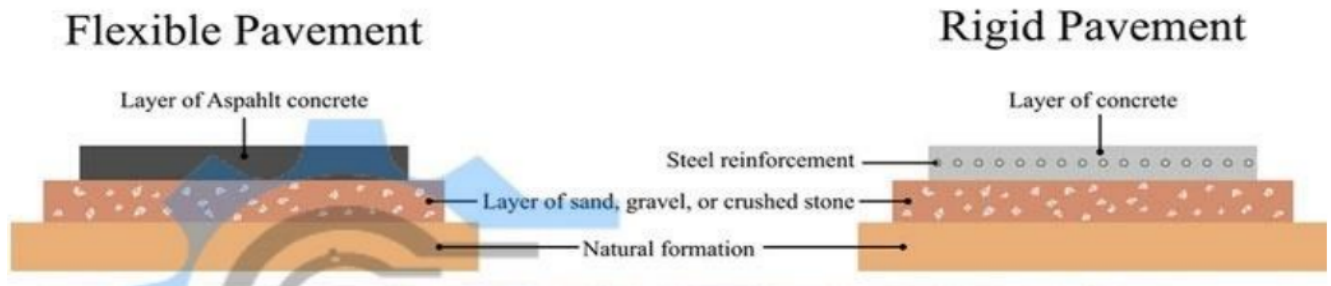
- Rigid pavement

Both these pavements have unique characteristics that make them suitable for specific environments



**Rigid pavements** are made of concrete slabs that are placed on a prepared subgrade. The slabs are **typically 4 to 10 inches** thick and are reinforced with steel bars to prevent cracking. Rigid pavements are strong and durable, and they can withstand heavy traffic loads. They are also relatively low-maintenance, as they do not require frequent sealing or resurfacing.

**Flexible pavements** are made of asphalt concrete, which is a mixture of asphalt binder, aggregate, and filler. The asphalt concrete is laid down in layers on a prepared subgrade. The thickness of the pavement varies depending on the traffic load and the strength of the subgrade. Flexible pavements are more flexible than rigid pavements, and they can conform to the movement of the subgrade.



Flexible Pavements	Rigid Pavements
<ul style="list-style-type: none"> <li>Flexible pavement comprises four layers, including the Sub Grade, Sub Base, Base course, and Surface course.</li> </ul>	<ul style="list-style-type: none"> <li>Rigid pavement is constructed from Portland Cement Concrete (PCC) and generally consists of three layers, including the Subgrade, Base course, and Surface course.</li> </ul>
<ul style="list-style-type: none"> <li>This type of pavement is made by using asphalt concrete (bitumen).</li> </ul>	<ul style="list-style-type: none"> <li>This type of pavement is made by using PCC or RCC.</li> </ul>
<ul style="list-style-type: none"> <li>Load transformation is through grain-to-grain contact.</li> </ul>	<ul style="list-style-type: none"> <li>Load transformation is through layer-to-layer action.</li> </ul>
<ul style="list-style-type: none"> <li>Initial cost is low</li> </ul>	<ul style="list-style-type: none"> <li>Initial cost is high</li> </ul>
<ul style="list-style-type: none"> <li>Joints are not required</li> </ul>	<ul style="list-style-type: none"> <li>Joints are required</li> </ul>
<ul style="list-style-type: none"> <li>Durability is less</li> </ul>	<ul style="list-style-type: none"> <li>Durability is high</li> </ul>
<ul style="list-style-type: none"> <li>If there is any failure at the bottom then that failure appears at the top.</li> </ul>	<ul style="list-style-type: none"> <li>If there is any failure at the bottom then, the slab will act as a bridge over the cavity.</li> </ul>
<ul style="list-style-type: none"> <li>Temperature variation has no any effect on the stress variation</li> </ul>	<ul style="list-style-type: none"> <li>Temperature variation effects the stress variation</li> </ul>
<ul style="list-style-type: none"> <li>Life span is short 15 years Repair work is easy</li> </ul>	<ul style="list-style-type: none"> <li>Long life span 30 years.</li> </ul>
<ul style="list-style-type: none"> <li>Maintenance cost is high</li> </ul>	<ul style="list-style-type: none"> <li>Maintenance cost is low</li> </ul>
<ul style="list-style-type: none"> <li>Requires less curing time</li> </ul>	<ul style="list-style-type: none"> <li>Requires much curing time.</li> </ul>
<ul style="list-style-type: none"> <li>Poor night visibility due to use of bitumen</li> </ul>	<ul style="list-style-type: none"> <li>Good night visibility</li> </ul>
<ul style="list-style-type: none"> <li>No glare due to sunlight</li> </ul>	<ul style="list-style-type: none"> <li>High glare due to sunlight</li> </ul>
<ul style="list-style-type: none"> <li>Easy to locate the underground works like pipe location, etc.</li> </ul>	<ul style="list-style-type: none"> <li>Difficult to do the underground works</li> </ul>
<ul style="list-style-type: none"> <li>Thickness is more</li> </ul>	<ul style="list-style-type: none"> <li>Thickness less</li> </ul>
<ul style="list-style-type: none"> <li>Design depends upon the subgrade strength</li> </ul>	<ul style="list-style-type: none"> <li>Design not depends on subgrade</li> </ul>

## **Classification of Highways**

The classification based on location and function should be a more acceptable classification for a country as they may be defined clearly. The Nagpur Plan divides roads in India into 5 main categories:

1. National Highways (NH)
2. State Highways (SH)
3. Major District Roads (MDR)
4. Other District Roads (ODR)
5. Village roads (VR)

Expressways were added as an additional category.

### **National Highways –**

- These are main highways running through the length and breadth of India, connecting all major ports, state capitals, large industrial and tourist centers including roads for strategic movement for the defense of India.
- These roads reduce travel time substantially, open up backward areas and help economic growth.
- All the NHs are assigned the respective numbers. The highway connecting Delhi-Ambala Amritsar is denoted as NH-1 Bombay-Agra road as NH-3, etc.

### **State Highways –**

They are the arterial roads of a state that connect to NHs of adjacent states, district headquarters and important cities within the state and are also linked to district roads.

### **Major District Roads –**

They are roads within a district serving areas of production and markets and connecting those with each other or with the main highways of a district. The MDR has a lower speed than NH/SH.

### **Other District Roads –**

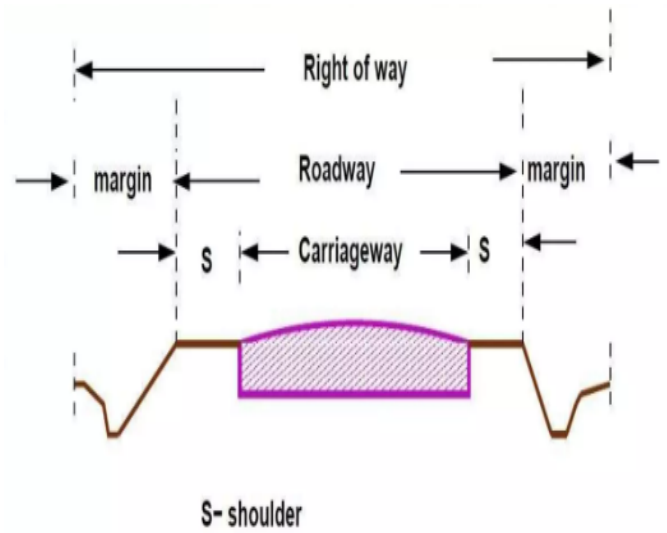
These roads serve rural areas of production and provide them with outlets to market centers, taluk headquarters, block development, headquarters or other main roads.

### **Village Roads –**

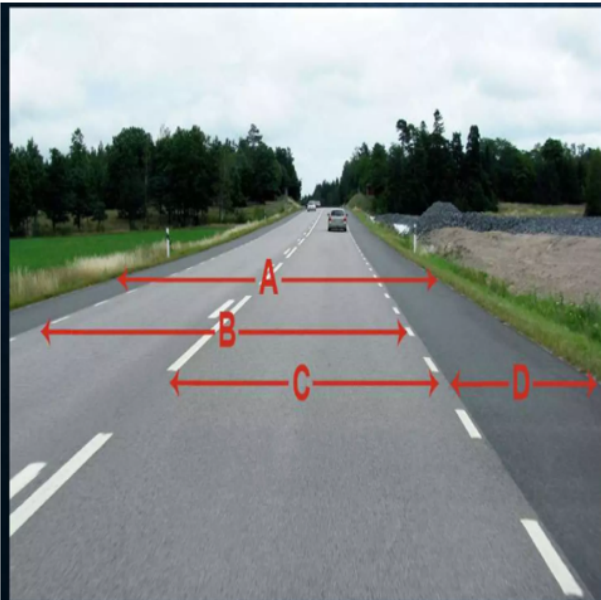
They connect villages or groups of villages with each other or to the nearest road of a higher category.

## Basic Components of a Road

- The basic components of the highway are the **Carriage way or pavement, Road way or formation width, Camber or cross slope, Kerbs, Medians, Road margins, Right of way ( ROW).**
- These geometric elements are designed and influenced by the psychology of the driver, the characteristics of the vehicle and the traffic of the region.
- Highway safety is ensured by fulfilling the management of these elements in a skillful manner.
- The basic components of a highway are explained briefly with the help of figure-1 showing the highway constructed in cutting and on an embankment.



A typical Right of way (ROW)

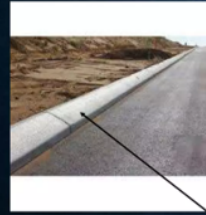


A = Roadway  
B = Carriage way  
C = Lane  
D = Shoulder

11

## CURB/KERB

It is the dividing line between carriageway and footpath.



Kerb

21

4-lane divided carriage way or dual carriage way

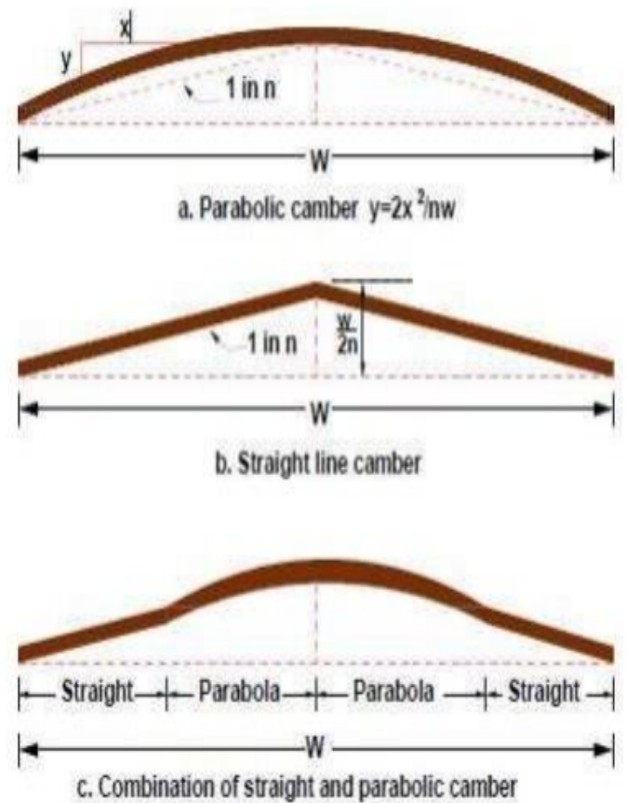


10

## Cross Slope or Camber

Cross Slope or camber is the slope that is provided in the transverse direction of the pavement or carriageway, as shown in figure. The cross slope helps to **drain off the rainwater** from the road surface. Inadequate cross slope results in the flooding of water over the pavement, which results in deterioration of the highway.

The value of the slope is dependent on the type of materials used for road construction and the amount of rainfall in the region. Generally, the value of cross slope varies from 1 in 60 to 1 in 25.



## **Carriageway or Pavement**

- The paved portion of the highway or the road over which the traffic is meant to move is called the pavement or the carriageway.
- The pavement width is dependent on the width of the traffic lanes and the number of lanes planned for construction.
- A traffic lane is defined as a carriageway or pavement that is designed for the movement of one line of traffic. Generally, for **single lanes** with a maximum width of **2.44 m**, the width of the lane is desirable to be **3.75 m**. For the pavements designed to have two or more lanes, the width is supposed to be 3.5 m.

## **Medians**

Medians are traffic separators whose main function is to prevent the collision of the vehicles that are moving in the opposite direction on the adjacent lanes.

## **Curbs**

The boundary between the pavement and the shoulder is called as curbs. Curbs are desirable to be constructed for urban roads.

## **Road Margins**

Road margin includes:

1. Shoulders
2. Bus Bays
3. Parking lanes
4. Sidewalks or footpaths



**Shoulders:** These are provided along the road edge as shown in the figure above. This area serves the purpose of accommodating vehicles that are compelled to be taken out of the pavement or the roadway. These also act as a service lane for the vehicles that have broken down.

**Bus Bays:** Bus bays are constructed by recessing the curb. Hence, there is no conflict with the moving traffic.

**Parking Lanes:** Parking lanes are provided for urban road construction hence allowing for curb parking.

**Footpaths or Sidewalks:** When the vehicular and pedestrian traffic is heavy, a special area is allotted for the movement of pedestrians. The area is called footpaths or sidewalks. This is provided to protect the pedestrian thus decreasing accidents.

### **Width of Roadway**

The width of the roadway or the width of the formation is equal to the sum of the width of the pavement (including the separators if any) and the shoulders.

### **Right of Way**

- The area of the land acquired for the road along its alignment is termed as the right of way. Land width is defined as the width of this acquired land.
- The right of way is dependent on the importance of the road and the possibility of future development.

## **Urban Roads**

Urban roads are classified based on their purpose, capacity, and role in managing traffic within urban areas. These classifications help in efficient urban planning and ensuring seamless connectivity. The five primary types of urban roads are outlined below:

The urban roads are classified as:

1. Expressways
2. Arterial roads
3. Sub-arterial roads
4. Collector streets
5. Local streets

### **1. Expressways**

**Purpose:** High-speed roads designed for long-distance, uninterrupted travel within and across urban areas.

**Characteristics:** Limited access with no direct connections to properties. Grade-separated intersections to avoid traffic disruptions.

Dedicated lanes for vehicles only, often excluding pedestrians and non-motorized traffic.

**Examples:** Urban freeways, elevated corridors.

### **2. Arterial Streets**

**Purpose:** Serve as the primary network for urban traffic, connecting major areas of the city.

**Characteristics:**

- High capacity for moving large volumes of traffic.
- Intersections with signals to manage traffic flow.
- Facilitate movement between different parts of the city rather than direct access to properties.

**Examples:** City boulevards or main roads.

### **3. Sub-Arterial Streets**

Purpose: Supplement arterial streets by distributing traffic to and from arterial roads.

Characteristics:

Moderate traffic volumes compared to arterial streets. Connect neighborhoods to arterial roads and other major points of interest. Some level of access to adjacent properties.

Examples: Secondary city streets leading to commercial or residential areas.

### **4. Collector Streets**

Purpose: Collect and channel traffic from local streets to arterial or sub-arterial roads.

Characteristics:

Moderate traffic speeds and capacity. Provide access to residential, commercial, or mixed-use areas. Balance between mobility and property access.

Examples: Neighborhood main streets or roads leading to schools or local businesses.

### **5. Local Streets**

Purpose: Provide direct access to individual properties, such as homes and small businesses.

Characteristics: Low traffic volumes and slow speeds. Primarily for local residents and light traffic. No through traffic or major transportation functions.

Examples: Residential streets, alleys.

## Basic Requirements of Urban Roads

The design and construction of urban roads require careful planning and consideration of various factors to ensure the safety, functionality, and efficiency of the road network in urban areas.

1. **Right-of-Way:** Sufficient land or right-of-way is needed to accommodate the road, including its lanes, shoulders, sidewalks, and other necessary elements. This may require land acquisition and adherence to zoning regulations.
2. **Alignment and Geometry:** The road should be designed with appropriate alignment, horizontal and vertical curves, grades, and intersections to ensure smooth traffic flow, safety, and visibility.
3. **Lane Configuration:** The number of lanes on urban roads varies based on traffic volumes. Roads may include single lanes in each direction, multiple lanes in each direction, or even reversible lanes depending on the urban density and traffic patterns.
4. **Road Pavement:** Urban roads should have a durable and smooth pavement surface made of materials like asphalt or concrete. The choice of pavement material depends on factors like traffic volume, climate, and budget.
5. **Drainage:** Proper drainage systems, including stormwater drains and gutters, are necessary to manage rainwater runoff and prevent flooding, erosion, and waterlogging.
6. **Sidewalks:** Sidewalks or footpaths are essential for pedestrian safety and mobility. They should be well-maintained, provide accessible crossings, and be separate from vehicular traffic where possible.
7. **Bicycle Lanes:** In urban areas, dedicated bicycle lanes or bike-sharing systems can encourage sustainable transportation and improve road safety for cyclists.

## **Various types of roads**

The Indian Road transport system consists of a network of various types of roads that serve the country's diverse transportation needs. These roads can be broadly categorized into the following types:

1. **National Highways (NH):** National Highways are the major road arteries in India, connecting various states and major cities. They are part of the National Highway Development Project (NHDP) and serve as the backbone of the Indian road network. These roads are usually well-maintained and have multiple lanes to facilitate high-speed and long-distance travel.
2. **State Highways (SH):** State Highways are roads that connect major cities and towns within a particular state. They are maintained and managed by the respective state governments and are crucial for intra-state transportation.
3. **District Roads (DR):** District Roads are feeder roads connecting rural and urban areas within a district. They are essential for local transportation, agricultural activities, and providing access to remote villages.
4. **Village Roads (VR):** Village Roads, also known as Rural Roads, are local roads that serve rural and remote areas, connecting villages to each other and to the broader road network. These roads are essential for rural development and access to basic services.

5. **Border Roads (BR):** Border Roads are strategically important roads along India's international borders. They are maintained by the Border Roads Organization (BRO) and are vital for defence, connectivity in remote regions, and cross-border trade.

6. **Expressways:** Expressways are high-speed, controlled-access highways with limited entry and exit points. They are designed for rapid long-distance travel and are gradually being developed in India to improve connectivity and reduce travel times.

**Urban Roads:** Within cities and urban areas, there are various types of roads, including arterial roads, collector roads, and local streets. These roads serve the transportation needs of urban populations and support economic activities.

8. **Special Roads:** Special roads can include those designed for specific purposes, such as industrial roads, port access roads, and mining roads, which cater to the requirements of particular industries or sectors.

9. **Circuit Roads:** These are roads that encircle and connect important tourist or religious sites, improving access for visitors and stimulating local tourism.

10. **Coastal Roads:** Coastal roads run parallel to India's coastline and are essential for coastal trade, tourism, and connecting coastal towns and cities.

11. **Mountain Roads:** Mountain roads traverse hilly and mountainous regions, often featuring steep gradients and sharp curves. They are important for connectivity in regions like the Himalayas.

12. **Jungle and Forest Roads:** These roads cut through dense forests and jungles, supporting forestry operations, and wildlife conservation, and providing access to remote areas.

13. **Waterfront Roads:** In areas with abundant water bodies, waterfront roads run alongside rivers, lakes, or canals, aiding transportation and trade by water.