STUDY MANUAL ON HIGHWAY ENGINEERING

Class 10

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Chapter 1

Introduction

1.1 Explore Different modes of transportation and Benefits of roads.

There are several modes of transportation, including:

i) **Road transportation:**

This includes cars, buses, motorcycles, trucks, and other vehicles that operate on roads. Road transportation provides door to door service. Service can be provided with high (blacked topped or reinforced concrete) to low budged (earthen) road. Road can be upgraded without suspending the road service.

Fig 1.1: Roadways

ii) **Rail transportation:**

This mode of transportation involves trains that operate on tracks. Road network is fixed, and fixed origin and destination. Large number of passengers can travel at a time. Needs high initial investment for construction of this mode of transportation system, but low travel cost.

Fig 1.2: Railway

iii) Air transportation:

Fig 1.3: Airways

This includes planes, helicopters, and other aircraft that operate in the air. Fixed origin and destination. Needs large initial investment for construction of this mode of transportation. Fastest mode of transportation. Travel cost in more than other mode of transportation.

iv) Water transportation:

Fig 1.4: Waterway

This includes boats, ships, and other watercraft that operate on water. Needs high initial investment to construct this mode of transportation. Generally goods from cross country trade were transported by this system. Boat, watercraft were used to travel in smaller distance.

Each mode of transportation has its benefits and drawbacks, and the choice of mode often depends on the distance to be traveled, the time available, the cost, and other factors.

Road transportation is a popular mode of transportation due to its convenience and accessibility.

Some of the benefits of roads include:

Connectivity: Roads provide connectivity between different places and regions. They allow people to travel to and from work, school, and other places, and facilitate the movement of goods and services.

Flexibility: Roads can be built almost anywhere and can be easily modified to accommodate changes in traffic patterns or land use.

Cost-effectiveness: Compared to other modes of transportation, such as air or rail, road transportation is generally less expensive, making it accessible to a broader range of people.

Speed: In urban and suburban areas, road transportation can often be faster than other modes of transportation, especially during peak traffic times.

Convenience: Personal vehicles, such as cars and motorcycles, provide individuals with the ability to travel where and when they want, without having to rely on schedules or routes.

Employment: Roads provide jobs for many people in the transportation industry, including drivers, mechanics, and construction workers.

Overall, roads are an essential part of modern transportation infrastructure, and they play a crucial role in connecting people and goods across different regions.

1.2 Throw light on Importance of roads for Nepal.

Roads are of significant importance for Nepal, given its geography and economic situation. Nepal is a landlocked country with a diverse topography, including the Himalayan Mountains, hills, and Terai plains. Nepal has limited access to the sea, making it heavily reliant on land-based transportation to connect with the outside world.

The following are some of the reasons why roads are essential for Nepal:

Connectivity: Roads are crucial for connecting different parts of the country, including remote and inaccessible areas, which otherwise may be isolated. Improved road connectivity can help bring essential goods and services to these regions, thereby reducing regional disparities.

Trade: Nepal relies heavily on trade with its neighboring countries, such as India and China. Roads play a crucial role in facilitating cross-border trade and transport of goods and services.

Tourism: Nepal is famous for its natural beauty, including the Himalayan Mountains, national parks, and cultural heritage sites. Roads are essential for developing and promoting tourism in Nepal, which can contribute significantly to the country's economy.

Agriculture: Agriculture is the primary source of livelihood for many people in Nepal, and roads are crucial for transporting agricultural products from rural areas to urban centers for processing and distribution.

Disaster management: Nepal is vulnerable to natural disasters such as earthquakes, floods, and landslides. Roads play a crucial role in facilitating relief and rescue operations during such emergencies.

Employment: The construction and maintenance of roads can provide employment opportunities for many Nepali, helping to alleviate poverty and promote economic growth.

In conclusion, roads are essential for Nepal's economic development, social progress, and regional integration. The government of Nepal has recognized the importance of roads and has prioritized investments in road infrastructure development to improve the country's connectivity and promote economic growth.

1.3 Classify roads according to NRS.

NRS 2070 is the Nepalese Standard for Road Classification. According to this standard, roads are classified under two headings a) Administrative Classification and Technical/ Functional Classification of road.

The Administrative classification is as follows:

National Highways: These are major roads that connect major cities and districts within Nepal and also serve as international trade routes. National highways are designated as "NH" and are numbered sequentially. For Example: Mahendra Highway, Tribhuvan Highway, BP Highway etc.

Feeder Roads: These are local roads that connect district and regional head headquarter with the national roads. Feeder roads are designated as "FR" and are numbered sequentially. For Example Janakpur-Dhalkebar Road.

District Roads: These are roads that connect district headquarters to the villages/ town, market place. For example Chakmake to Sindhulimadhi Road.

Urban Roads: These are roads that connect different areas within an urban area or city. Urban roads are developed and maintained by the local government, such as municipalities.

The Technical/ Functional classification is as follows:

Class I: These are highest standard with divided carriageway and access control with average daily traffic (ADT) more than 20000 PCU (Passenger Car Unit) and perspective period is more than or equal to 20 years. In plain terrain the design speed for these type of road is 120 Km/hr.

Class II: Average daily traffic (ADT) more than 5000 to 20000 PCU (Passenger Car Unit) and perspective period is more than or equal to 20 years. In plain terrain the design speed for these type of road is 100 Km/hr.

Class III: Average daily traffic (ADT) more than 2000 to 5000 PCU (Passenger Car Unit) and perspective period is more than or equal to 20 years. In plain terrain the design speed for these type of road is 80 Km/hr.

Class IV: Average daily traffic (ADT) less than 2000PCU (Passenger Car Unit) and perspective period is more than or equal to 20 years. In plain terrain the design speed for these type of road is 60 Km/hr.

1.4 Describe Role of roads in rural development.

Roads play a crucial role in the rural development of a region. They provide essential transportation infrastructure that connects rural areas to urban centers, markets, and various social services. Here are some key roles of roads in rural development:

Connectivity and Accessibility: Roads facilitate better connectivity and accessibility by linking rural areas to towns, cities, and other regions. Improved transportation infrastructure allows for the easy movement of people, goods, and services, reducing isolation and enhancing social and economic opportunities for rural communities.

Market Access: Well-connected roads provide rural communities with improved access to markets. Farmers and producers can transport their agricultural products and goods to urban areas efficiently, increasing their reach and potential customer base. This accessibility promotes economic growth and rural entrepreneurship.

Employment Opportunities: The construction and maintenance of roads create employment opportunities for the local population. Additionally, improved road connectivity attracts investments, encourages tourism, and facilitates the establishment of industries and businesses in rural areas. This, in turn, generates employment opportunities for the local residents.

Social Services and Healthcare: Good road networks enable the delivery of social services, such as education, healthcare, and emergency services, to rural communities. Schools, medical facilities, and other essential services can reach remote areas more effectively, improving the quality of life for rural residents.

Agricultural Development: Roads play a vital role in promoting agricultural development in rural areas. Farmers can access agricultural inputs like seeds, fertilizers, and machinery more easily. They can also transport their produce to markets promptly, reducing post-harvest losses and increasing their income. Furthermore, the availability of reliable transportation encourages investment in agro-processing industries, leading to value addition and increased employment opportunities.

Poverty Alleviation: Improved road infrastructure in rural areas can contribute significantly to poverty alleviation. It enables better access to economic opportunities, markets, education, and healthcare, thereby improving the standard of living for rural communities. The increased mobility and economic activities resulting from better roads can help lift people out of poverty and reduce income disparities.

Disaster Management: Well-planned road networks also assist in disaster management and emergency response in rural areas. During natural disasters or emergencies, such as floods or earthquakes, roads provide lifelines for evacuation, relief operations, and the delivery of essential supplies and aid to affected areas.

Overall, the role of roads in rural development cannot be overstated. They enhance connectivity, promote economic growth, facilitate access to social services, and contribute to poverty reduction. Investment in rural road infrastructure is crucial for fostering inclusive and sustainable development in rural areas.

1.5 Introduce History of development of roads.

The historical development of road construction can be traced back thousands of years, with civilizations around the world constructing various types of roads to facilitate transportation and trade. Here is a broad overview of the major milestones in road construction throughout history:

1. Roman Road
2. Tresagut construction
3. Telford construction
4. Macadam construction

1. Roman Road

Roman roads were constructed during the period of roman civil. These roads were built of stone blocks of considerable thickness. These roads were mostly constructed straight.

Large foundation stones in lime mortar 10 to 20 cm thick was provided on hard soil stratum, the 25 to 40 cm thick broken stones in lime mortar provided. Above that layer 25 to 40 cm thick lime concrete used and finally 10 to 15 cm thick large stone slabs in lime mortar provided as road surface.

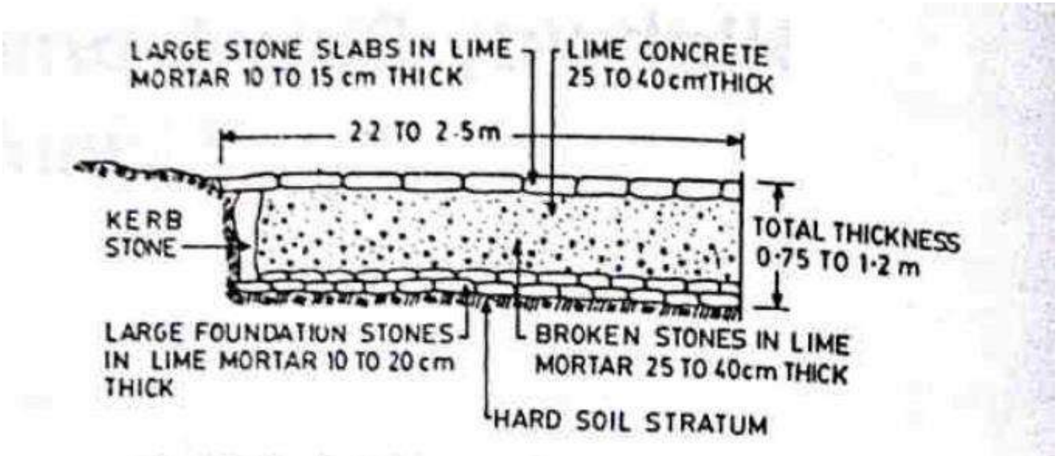

Figure 1.5: Roman road construction (Highway Engineering by: Khanna and Justo)

<u>Some features of roman roads</u>

- Regardless of gradients
- Soft soil was excavated & removed till hard stratum clay
- Total thickness 0.75 to 1.2m.
- Kerb stone of 50 to 80 cm long provided between natural soil and filling materials at both side corner of road.
- Lane width 2.2 to 2.5 m and total width 4.4 to 5 m.
- Roads were very costly.

2. Tresagut construction

Pierre Tresagut develop an improved method of road construction in 1964 A.D. The main feature of his construction method was the thickness of road limited to 30 cm.

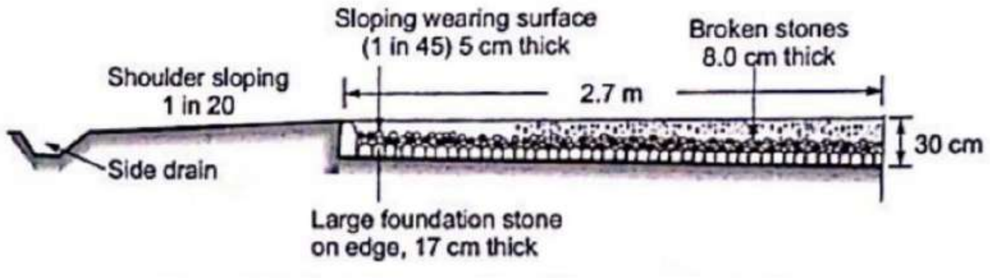

Figure 1.6: Tresagut road construction (Highway Engineering by: Khanna and Justo)

Some features of Tresagut roads

- Large Foundation stone on edge of road about 17 cm thick.
- Broken stone layer of 8 cm thick above the foundation stone.
- Wearing course of 5 cm thick above the broken stone with slope 1 in 45 from center to edge.
- Provision of side drain.
- Provision of shoulder with slope 1 in 20.
- As compare to the Roman Road the cost of construction greatly reduced because overall depth of road reduces from 1.2 m to 30 cm.

3. Telford construction

Thomos Telford (1757-1834) was the founder of institution of civil engineer at London. He began his work in early 19th century. He develop an improved method of road construction, in which large foundation stones of varying thickness were used and overall thickness limited to 36 mm to 41 mm.

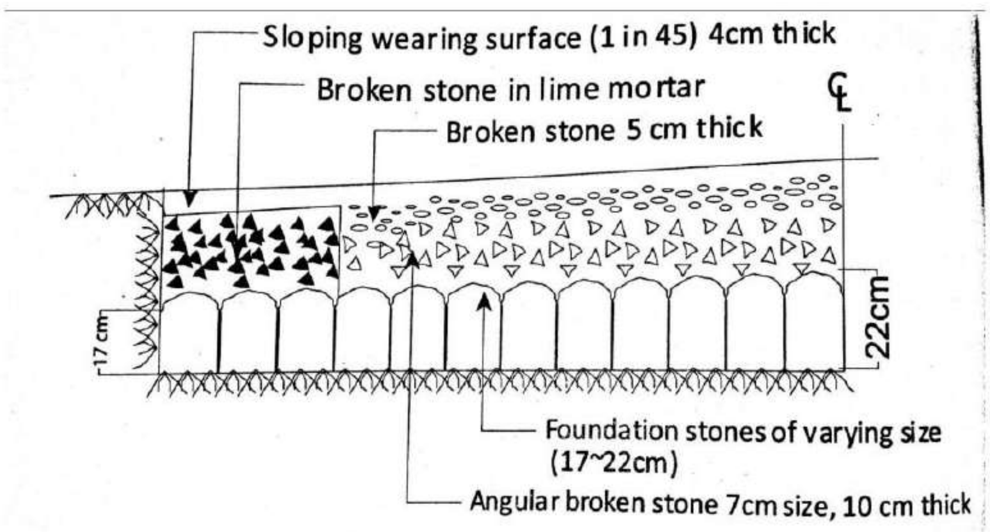

Figure 1.7: Telford road construction (dreamcivil.com)

Some features of Tresagut roads

- Large Foundation stone of varying thickness (17 to 22 cm) were used.
- Angular Broken stone layer of 10 cm thick above the foundation stone.
- Broken stone layer of 5 cm thick provided just above the angular broken stone layer.
- At the edge side of the angular and broken stone broken stones with lime mortar were used about 15 cm.
- Wearing course of 4 cm thick above the broken stone with slope 1 in 45 from center to edge.

4. Macadam construction

John Macadam (1756-1836) was the surveyor general of road in England. His new concept of road construction became known by the year 1827. Overall thickness limited to 25 cm.

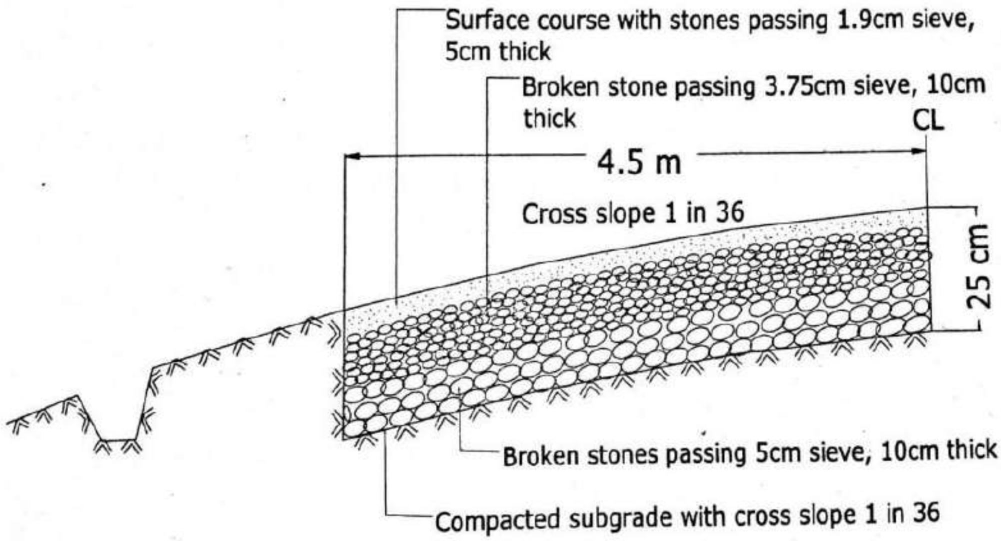

Figure 1.8: Macadam road construction (dreamcivil.com)

Some features of Tresagut roads

- Subgrade prepared and compacted with the cross slope of 1 in 36.
- Broken stone layer (passing through 5 cm sieve) of 10 cm thick provided just above the subgrade.
- Broken stone layer (passing through 3.75 cm sieve) of 5 cm thick provided above the first stone layer.
- Wearing course (broken stone passing through 1.9 cm sieve) of 10 cm thick provided.
- Provision of side drain.
- Overall thickness of road 25 cm.

1.6 Differentiate and compare Rural and urban road, advantages and disadvantages.

Difference between Rural and Urban Road

Rural Road	**Urban Road**
These roads are located in rural areas, typically outside towns and cities. They often pass through agricultural or sparsely populated regions and may connect villages, farms, or rural communities.	Urban roads are found within towns and cities, where there is a higher population density and urban development. They traverse built-up areas, residential neighborhoods, commercial districts, and industrial zones.
Traffic on rural roads is generally lower compared to urban roads. They usually experience less congestion and have fewer vehicles, except during specific periods like holidays or harvest seasons.	Urban roads are characterized by higher traffic volumes due to the concentrated population and economic activities in cities. They experience more congestion and have a diverse mix of vehicles, including cars, buses, taxis, motorcycles, bicycles, and pedestrians.
Due to lower traffic and wider open spaces, rural roads often have simpler designs and fewer traffic control measures. They may have wider lanes, fewer intersections, and lower speed limits compared to urban roads.	Urban roads require more complex designs and traffic management systems. They typically have narrower lanes, numerous intersections, traffic signals, pedestrian crossings, and other traffic control devices to handle higher traffic volumes and ensure the safety of pedestrians and motorists.
Infrastructure on rural roads is often basic, with single or dual carriageways, gravel or paved surfaces, and fewer amenities. Maintenance and repairs may be less frequent due to lower usage and budget constraints.	Urban roads tend to have more advanced infrastructure, including multiple lanes, sidewalks, street lighting, signage, and public transportation facilities. They require regular maintenance due to heavier usage and are more likely to be equipped with amenities like bus stops, parking lots, and pedestrian infrastructure.
Rural roads play a crucial role in providing connectivity to isolated rural areas. They connect villages, farms, and rural communities to towns, markets, and essential services such as schools, healthcare facilities, and transportation hubs.	Urban roads facilitate intra-city movement and provide access to residential areas, commercial centers, educational institutions, healthcare facilities, and other urban amenities. They support commuting, goods transportation, and the functioning of urban economies.

Advantages of Rural Road

Connectivity: Rural roads provide essential connectivity to remote and isolated areas, allowing residents to access services such as healthcare, education, markets, and employment opportunities. They enable transportation of goods and services to and from rural communities, fostering economic development.

Agriculture and Rural Economy: Rural roads support the agricultural sector by facilitating the transportation of crops, livestock, and agricultural inputs. They enable farmers to reach markets more easily, reducing post-harvest losses and improving their livelihoods. Additionally, improved rural transportation can attract investments and stimulate rural businesses.

Natural Resource Access: Rural roads provide access to natural resources like forests, mines, and water sources. This access is crucial for activities such as forestry, mining, fishing, and water management, supporting local industries and livelihoods.

Social Integration: By connecting rural communities and promoting interaction, rural roads enhance social integration. They enable people to visit friends and relatives, participate in community events, and access social services. This helps foster a sense of community and improves quality of life in rural areas.

Emergency Services: Rural roads allow emergency service providers, such as ambulances and fire brigades, to reach remote locations quickly. Prompt access to emergency medical care and disaster response services can save lives and minimize property damage in rural areas.

Disadvantages of Rural Road

Cost and Maintenance: Rural roads often cover vast areas with relatively low population density, making their construction and maintenance more expensive per kilometer compared to urban roads. Limited financial resources and challenges in accessing remote locations can lead to inadequate maintenance and slower repairs.

Limited Infrastructure: Rural roads may lack some essential infrastructure found in urban areas, such as street lighting, sidewalks, and public transportation facilities. This can result in reduced safety for pedestrians, cyclists, and motorists, especially during nighttime travel.

Accessibility Challenges: In certain regions, rugged terrain, extreme weather conditions, and inadequate drainage systems can make rural roads prone to erosion, landslides, and flooding. This can disrupt transportation and isolate communities during adverse weather events, affecting access to services and emergency assistance.

Longer Travel Distances: Due to the dispersed nature of rural communities, residents often need to travel longer distances to access essential services, education, healthcare, and employment opportunities. This can increase travel time, transportation costs, and inconvenience for rural residents.

Limited Public Transportation: Public transportation options in rural areas are often limited, with fewer bus routes or scheduled services. This can result in challenges for individuals without private vehicles, making it harder for them to access essential services and participate in economic and social activities.

Advantages of Urban Road

Improved Accessibility: Urban roads provide enhanced accessibility within cities, allowing residents to easily reach various destinations such as workplaces, schools, shopping centers, healthcare facilities, and recreational areas. They enable efficient movement and connectivity within urban areas.

Economic Development: Well-designed urban road networks support economic growth and development. They facilitate the transportation of goods and services, providing a vital link between businesses, suppliers, and consumers. Efficient urban roads can reduce transportation costs, increase productivity, and attract investments.

Public Transportation: Urban roads are crucial for the functioning of public transportation systems, including buses, trams, and light rail. They enable efficient movement of public transit vehicles, which helps reduce congestion, improve air quality, and provide affordable transportation options for residents.

Safety Enhancements: Urban roads often incorporate safety features such as traffic signals, pedestrian crossings, and dedicated bike lanes. These measures help improve road safety for pedestrians, cyclists, and motorists by reducing the risk of accidents and promoting orderly traffic flow.

Infrastructure and Services: Urban roads are typically accompanied by supporting infrastructure and services. These may include street lighting, sidewalks, parking facilities, public amenities, and utilities such as drainage systems. Such infrastructure enhances the livability and functionality of urban areas.

Disadvantages of Urban Road

Congestion: One of the significant challenges of urban roads is traffic congestion. Higher population densities and increased vehicle ownership in cities lead to traffic bottlenecks, delays, and longer travel times. Congestion not only hampers productivity but also contributes to pollution and increased fuel consumption.

Air Pollution and Noise: The concentration of vehicles in urban areas contributes to air pollution, including emissions of greenhouse gases and harmful pollutants. Additionally, traffic noise can be a nuisance and impact the quality of life for residents living along busy urban roads.

Limited Space and Land Use: Urban areas often face constraints regarding available land for road expansion or new road construction. This limitation can make it challenging to accommodate growing traffic demands and can result in compromised road capacity and increased congestion.

Pedestrian and Cyclist Safety: Despite safety measures, urban roads can still pose risks to pedestrians and cyclists due to high traffic volumes, speeding vehicles, inadequate infrastructure, and driver behavior. Ensuring the safety and accessibility of vulnerable road users remains a priority for urban road planning and design.

Maintenance and Costs: Urban road networks require regular maintenance due to heavy usage and wear and tear. Maintenance and repairs can cause disruptions, road closures, and traffic diversions. The financial costs of constructing, maintaining, and upgrading urban roads can be substantial, often requiring significant investment from governments and transportation authorities.

1.7 Illustrate Types of feeder (Provincial and Local road) roads and overview in construction.

1.8 Recognize and draw different urban Road patterns.

Different types of road patterns are:

a) Rectangular or block pattern
b) Radial or star and block pattern
c) Radial or star and circular pattern
d) Radial or star and grid pattern
e) Hexagonal pattern
f) Minimum travel pattern

a) Rectangular or block pattern

In this pattern, the whole area is divided into rectangular blocks of plots, with streets intersecting at right angles. The main road which passes through the center of the area should be sufficiently wide and other branch roads may be comparatively narrow.

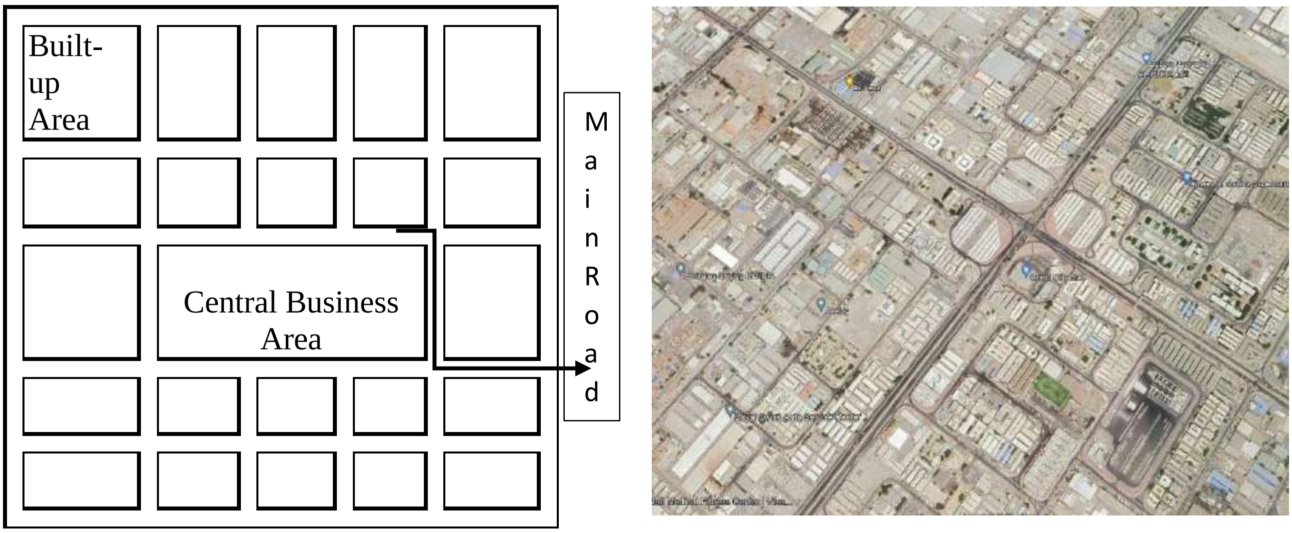

Figure 1.9: Rectangular or Block Pattern

b) Radial or star and block pattern

A radial or star and block pattern of road network is a combination of two different road patterns: the radial pattern and the block pattern. The radial pattern is characterized by a series of roads that radiate outward from a central point, while the block pattern is characterized by a grid-like arrangement of roads. When these two patterns are combined, the result is a network of roads that is both efficient and easy to navigate.

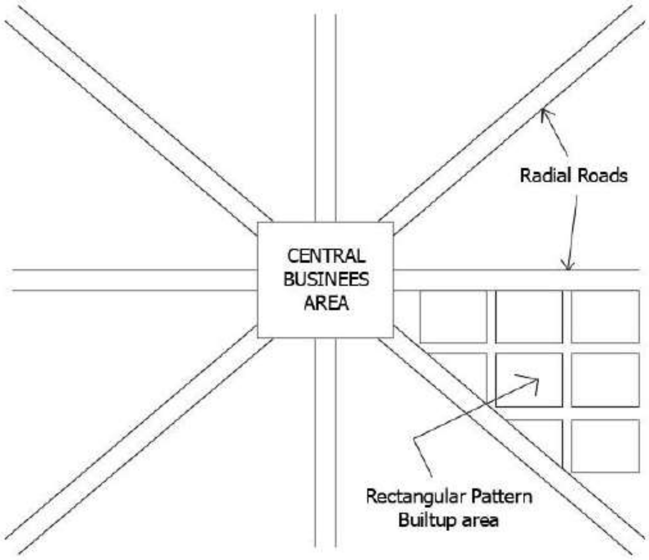

Figure 1.10: Radial or Star and Block Pattern

c) Radial or star and circular pattern

Radial or star and circular pattern is a type of road pattern in which the main roads radiate outward from a central point and are connected by concentric roads. This pattern is often used in cities and towns, as it can help to improve traffic flow and reduce congestion.

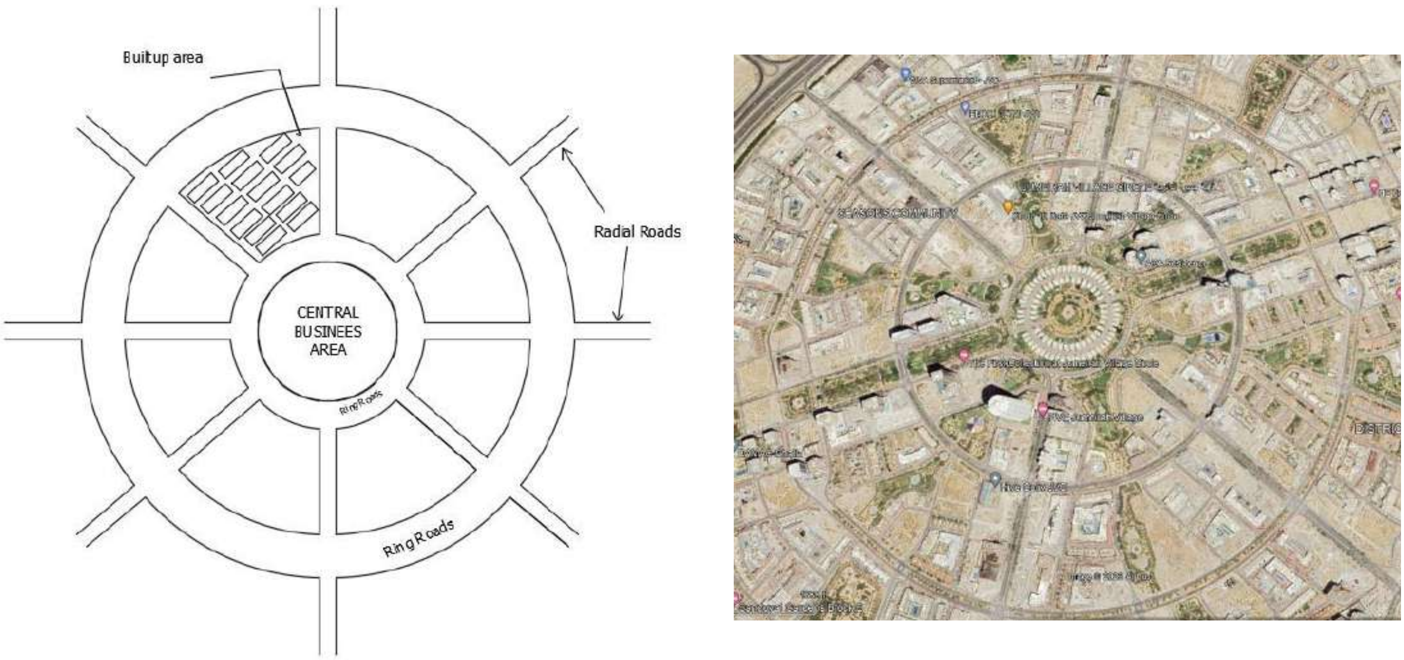

Figure 1.11: Radial or Star and Circular Pattern

d) Radial or star and grid pattern

A radial or star and grid pattern is a type of road network that combines radial and grid patterns. From the center, a radial network of roads radiates outward. The grid pattern is then used to interconnect the main radial streets. This type of road network is often used in planned communities, as it can provide efficient traffic flow and easy access to different parts of the community.

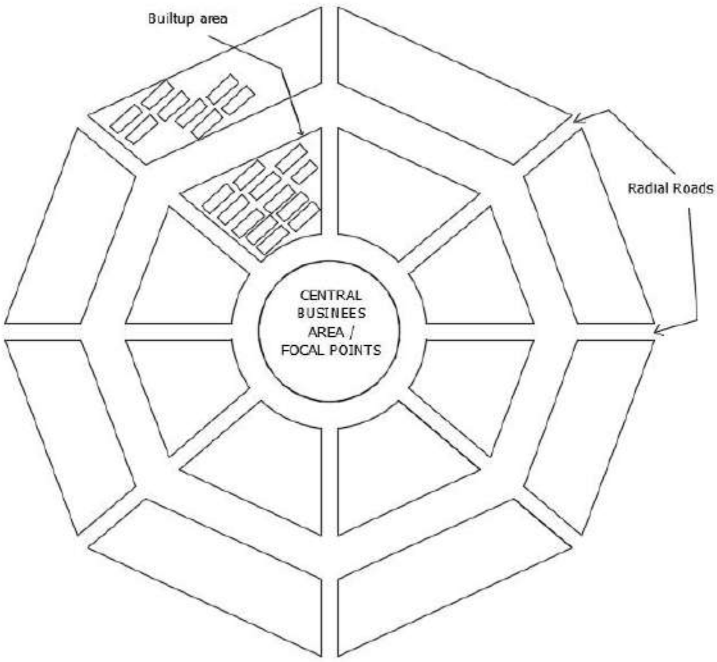

Figure 1.12: Radial or Star and Grid Pattern

e) Hexagonal pattern

A hexagonal road network is a type of road network that is made up of a series of hexagons. Each hexagon is surrounded by six other hexagons, and each road connects two adjacent hexagons. Hexagonal road networks are often used in planned communities, as they can be efficient and easy to navigate. They can also be used to create a more sustainable transportation system, as they can help to reduce traffic congestion and improve air quality.

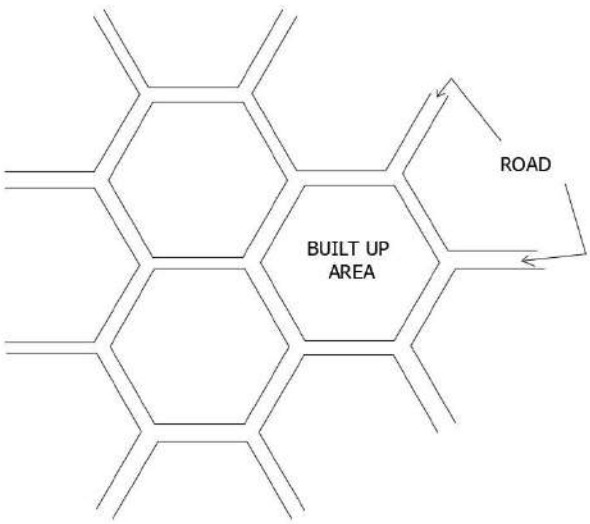

Figure 1.13: Radial or Star and Grid Pattern

f) Minimum travel pattern

A minimum travel pattern is a road network design that minimizes the total travel distance for all vehicles in the network. This can be achieved by using a variety of techniques, such as: grid system, radial system, circular system.

The best type of minimum travel pattern for a particular city will depend on the city's size, shape, and traffic patterns. For example, a grid system may be the most efficient type of minimum travel pattern for a large city with a lot of traffic, while a radial system may be the most efficient type of minimum travel pattern for a small city with less traffic.

Chapter 2

Road Alignment and Survey

2.1 Describe Fundamental principles of road alignment.

The position or the layout of the Centre line of the highway on the ground is called the alignment. Both a horizontal and vertical alignment of the road are included in the highway alignment. Straight lines, deviations, and horizontal curves are all included in horizontal alignment. The vertical alignment of highways includes changes in gradient and vertical curves.

Improper alignment would results the increase the construction cost, maintenance cost, vehicle operation cost and accident rate.

Once the road is aligned and constructed, it is not easy to change the alignment due to the increased cost of adjacent land and the building on the roadside, as well as the land value increasing significantly once the road is open to traffic, it is difficult to change the alignment of a road after it has been aligned and constructed. So it is not necessary to overstate the significance of giving careful thought to the alignment of the new road.

2.2 Point out Requirements of road alignment.

The basic requirement of road alignment between two terminal stations should be:

i) Short   ii) Easy   iii) Safe   iv) Economical

i) Short:-

The alignment should be as short as possible, as this will reduce the cost of construction and maintenance. It will also reduce the travel time for motorists.

ii) Easy:-

The alignment should be easy to construct and maintain. This means that it should avoid steep grades and sharp curves. It should also be located in areas where materials and labor are readily available.

iii) Safe:-

The alignment should be safe for both drivers and pedestrians. This means that it should have a smooth surface, clear sightlines, and be free of hazards such as potholes, sharp curves, and steep grades.

iv) Economical:-

The alignment should be as economical as possible to construct and maintain. This means that it should avoid unnecessary curves and grades, and should be located in areas where materials and labor are readily available.

2.3 Explain Factors which control the selection of road alignment.

Class and purpose of the road. The alignment of a road will vary depending on its class and purpose. For example, a high-speed highway will require a straighter alignment than a local road.

- **i)** **Obligatory points.** Obligatory points are locations that the road must pass through, such as bridges, tunnels, or towns. These points can have a significant impact on the alignment of the road.

- **ii)** **Type of vehicular traffic.** The type of vehicular traffic that will use the road will also affect its alignment. For example, a road that is used by heavy trucks will need to be designed differently than a road that is used by cars.

- **iii)** **Gradient.** The gradient of the road is the slope of the road. The gradient should be as gentle as possible to reduce the risk of accidents.

- **iv)** **Horizontal curves.** Horizontal curves are curves in the road that are aligned with the direction of travel. They are used to reduce the risk of accidents and to improve the comfort of drivers.

- **v)** **Sight distance.** Sight distance is the distance that a driver can see ahead of them. It is important to ensure that there is adequate sight distance at all times to reduce the risk of accidents.

- **vi)** **Obstructions.** The alignment of the road should be free from obstructions such as trees, buildings, and hills. These obstructions can reduce sight distance and increase the risk of accidents.

- **vii)** **Economic factors.** The cost of construction and maintenance is an important factor in the selection of road alignment. The alignment should be as economical as possible while still meeting all of the other requirements.

- **viii)** **Availability of construction materials.** The availability of construction materials can also affect the alignment of the road. The alignment should be selected in a way that minimizes the need for expensive materials.

- **ix)** **Environmental factors.** The alignment of the road should be designed to minimize its impact on the environment. This includes factors such as erosion, wildlife habitat, and water quality.

- **x)** **Social factors.** The alignment of the road should be designed to minimize its impact on the community. This includes factors such as noise, traffic congestion, and property values.

These are just some of the factors that control the selection of road alignment. The specific factors that are most important will vary depending on the specific project.

<u>* Obligatory points controlling alignment of road</u>

2.4 Describe Engineering survey for highway locations.

An engineering survey for highway location is a process of collecting data and information about the proposed route of a highway in order to determine its feasibility and cost. The survey typically includes the following steps:

Map study: A study of topographical maps and aerial photographs is conducted to identify possible routes for the highway.

Reconnaissance survey: A field survey is conducted to confirm the features indicated on the map and to collect additional data, such as the presence of wetlands, steep slopes, or other obstacles.

Preliminary survey: A more detailed survey is conducted to determine the exact alignment of the highway, the need for any bridges or tunnels, and the amount of earthwork that will be required.

Final location and detailed survey: A final survey is conducted to locate the highway on the ground and to collect data that will be used to design the highway, such as the width of the road, the grade of the road, and the location of curves and intersections.

The engineering survey for highway location is an important part of the planning process for any highway project. The data collected during the survey helps to ensure that the highway is designed and constructed in a safe and efficient manner.

Here are some of the factors that are considered during an engineering survey for highway location:

Topography: The surveyors will need to consider the topography of the area, including the presence of hills, valleys, and rivers.

Soil conditions: The surveyors will need to determine the soil conditions in the area, as this will affect the type of foundation that is needed for the highway.

Drainage: The surveyors will need to consider the drainage in the area, as this will affect the design of the culverts and bridges.

Traffic volume: The surveyors will need to estimate the traffic volume on the highway, as this will affect the width of the road and the number of lanes.

Environmental impacts: The surveyors will need to assess the environmental impacts of the highway, such as the impact on wildlife and wetlands.

The engineering survey for highway location is a complex process that requires the expertise of a team of surveyors, engineers, and environmental scientists. The data collected during the survey is essential for the successful planning and construction of any highway project.

Chapter 3

General definition of terms used in highway geometric design

3.1 Define Traffic volume, intensity, and lane, slip friction, skid.

Traffic volume is the number of vehicles that pass a given point on a road during a specific period of time. It is typically measured in vehicles per hour (veh/h).

Traffic volume is an important factor in determining the capacity of a road. The capacity of a road is the maximum number of vehicles that can safely travel on the road at a given time.

Traffic intensity is a measure of the average number of vehicles that are on a road at a given time. It is calculated by dividing the traffic volume by the length of the road. It is typically measured in vehicles per kilometer (veh/km).

Traffic intensity is a measure of how busy a road is. It is used to assess the need for traffic management measures, such as traffic signals or road widening.

Lane is a defined path for vehicles to travel in on a road. Lanes are typically separated by painted lines or raised curbs.

Lanes are important for safety and efficiency. They help to keep traffic moving in the same direction and to prevent head-on collisions.

Slip friction is the force that opposes the relative motion of two surfaces in contact. It is typically measured in units of force per unit area (N/m^2)

Slip friction is essential for safe driving. It allows drivers to control their vehicles and to stop in time to avoid accidents.

Skid is a loss of traction between a vehicle's tires and the road surface. This can happen when the tires are not properly inflated, the road is wet or icy, or the driver is driving too fast.

Skid occurs when slip friction is reduced. This can lead to loss of control and accidents.

3.2 Explain typical cross section in cutting and filling-definition of its elements.

Here are the cross sectional elements of highways:

Carriageway: The carriageway is the main driving surface of the road. It is typically made of bituminous or asphalt or concrete.

As per NRS 2070 width of carriage way

For single lane highway: 3.75 m

For multilane highway: 3.5 m

For intermediate lane: 5.5 m

Shoulders: The shoulders are the areas on either side of the carriageway that provide a place for vehicles to stop or park in an emergency. They are also used to provide lateral support for the carriageway.

As per NRS 2070 the minimum shoulder width for road class I, II, III & class IV should be 3.75 m, 2.5 m, 2.0 m & 1.5 m respectively.

Formation width: The formation with is the total width of carriageways, medians and shoulders.

Side slope: The side slope is the slope of the embankment's sides. It is typically 1:2 or 1:4. And side slope for cutting side, it is typically 1:1 (for ordinary soil) to almost vertical (for Hard rock) as per NRS 2070.

Right of way (ROW): The right of way is the area of land that is required for the construction and maintenance of the road. It includes the area of the carriageway, medians, the shoulders, the drains, footpath, and the side slopes.

As per NRS 2070 the right of way for Highways, Feeder Roads and District Roads should be 50 m, 30 m & 20 m respectively.

Drains: Drains are used to collect and remove rainwater from the road surface. They are typically located along the shoulders and at the toe of the embankment.

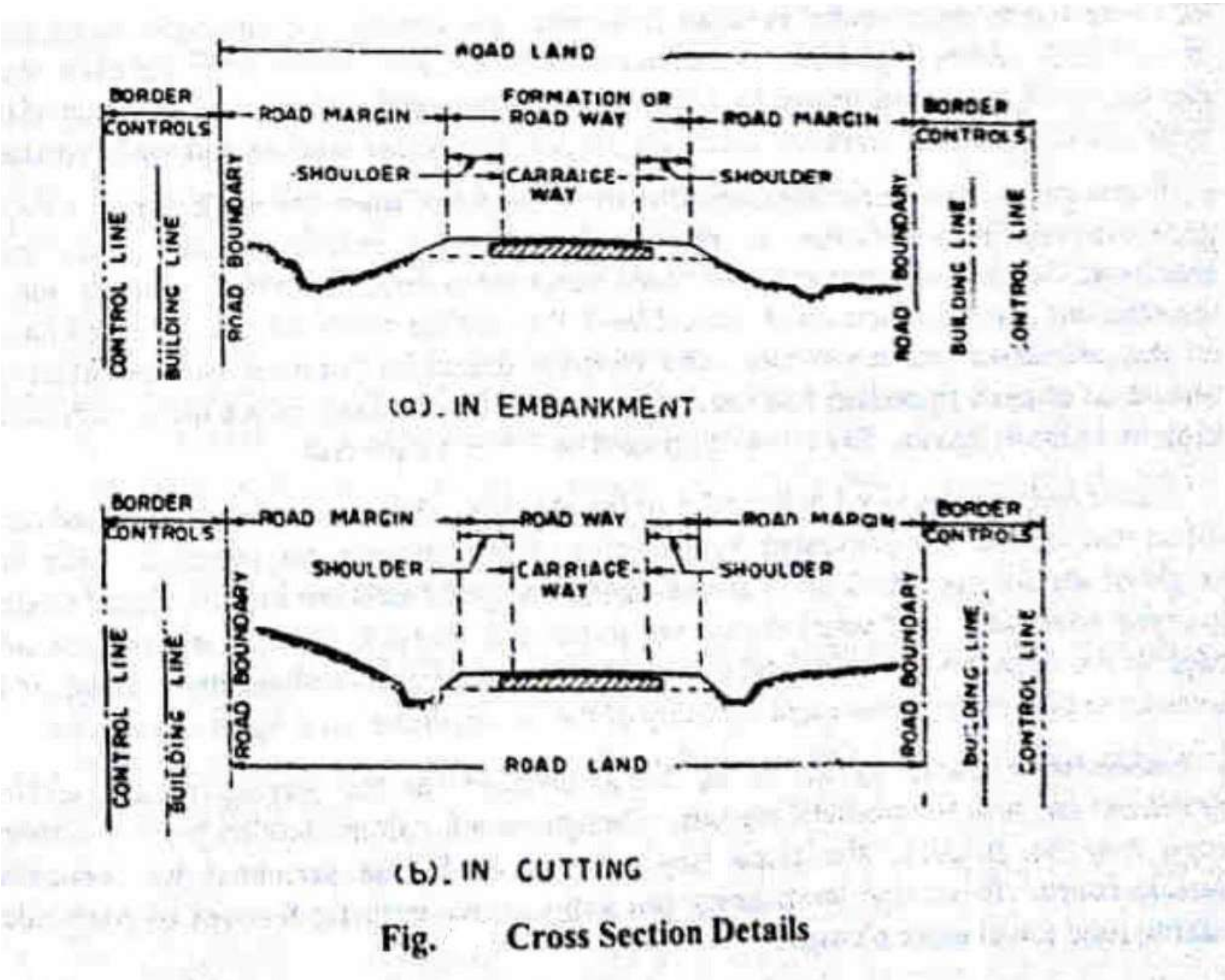

Figure 3.1: Cross section of road at filling and cutting (Highway Engineering by: Khanna and Justo)

3.3 Define Camber, super-elevation, extra-widening.

Camber is the slope provided to the road surface along the transverse direction. It is designed to ensure the proper drainage of water during rains.

The amount of camber provided on a road depends upon several factors such as the traffic volume, road width, and climate.

Roads with a high traffic volume require a greater amount of camber as compared to low traffic roads. Proper cambering not only increases the life of the road but also enhances passenger comfort.

Camber should be such that there is no waterlogging on the road surface. Excessive camber can cause discomfort to passengers and increase the risk of accidents.

As per NRS 2070 the camber for different types of pavement shown in table 3.1

Pavement Type	Cement Concrete	Bituminous	Gravel	Earthen
Camber %	1.5 to 2.0	2.5	4	5

Superelevation is the banking of the road on curves. It's designed to counteract the centrifugal force that pushes vehicles away from the center of the curve. During cornering, the vehicle at high speeds tends to lean to the outer side of the curve, making the maneuvering of the vehicle difficult.

Superelevation improves the handling of vehicles on the curved sections of roads, reducing the risk of accidents, and preventing high-speed vehicles from tipping over. It also enhances the comfort level of passengers.

The amount of **superelevation should** be based on speed limit and curve radius. Insufficient super-elevation can cause skidding and tipping over of high-speed vehicles.

Superelevation is calculated using the following formula

$$e = \frac{v^2}{127R} - f \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad \text{eq. 3.1}$$

Where,

e = superelevation, m/m,

v = design speed in Km/h,

R = radius of curve,

f = Co-efficient of lateral friction, depends on vehicle speed, which is shown in table 3.2

Design speed (Km/h)	120	100	80	60	40	30	20
Co-efficient of lateral friction, f	0.09	0.12	0.14	0.17	0.23	0.28	0.33

As per NRS 2070 the maximum super elevation for different terrain shown in table 3.3

Terrain	In Plain and Rolling Terrain	In snow bound area	In hilly area not bounded by snows
Superelevation, %	7	7	10

Extra-widening is a measure adopted in road construction where additional width is provided on the outer side of the curve. The extra width is provided to allow high-speed vehicles to cross each other comfortably.

Extra-widening prevents accidents by creating more space for vehicles, and it ensures safe overtaking of other vehicles without entering the opposite lane.

The **width of extra-widening depends** upon traffic volume and speed limit. Inadequate extra-widening can lead to dangerous driving situations.

Extra widening required, $W_e = \frac{nl^2}{2R} + \frac{V}{9.5\sqrt{R}}$

Here, n= number of lane, l= wheel base, R= ruling minimum radius of curve, V= design speed in Kmph.

Ruling minimum radius, $R=\frac{V^2}{127(e+f)}$, where, e=superelevation and f=friction of pavement

As per NRS 2070 the extra widening for different lane and radius of curves are shown in table 3.3

Radius of curve, m		20	20-40	40-60	60-100	100-300	>300
Extra width	Single lane	0.9	0.6	0.6	Nil	Nil	Nil
	Double lane	1.5	1.5	1.2	0.9	0.6	Nil
	Multi lane	0.75 n	0.75 n	0.6 n	0.45 n	0.3 n	Nil

3.4 Explain Sight distance and its types.

Sight distance is the length of visible roadway ahead for a driver to perceive and respond to any potential obstructions or hazards.

The driver's ability to see and react to upcoming road conditions is crucial to avoiding accidents and maintaining roadway efficiency.

For safety it is necessary that sight distance of adequate length should be available to permit drivers enough time and distance to control their vehicles.

There are two types of site distance

i. Stopping site distance (SSD) and
ii. Overtaking site distance (OSD)

Stopping site distance (SSD)

The minimum distance available on a highway at any spot should be of sufficient length to stop a vehicle traveling at design speed safely without collision with any other obstruction.

Stopping sight distance = Lag distance (Reaction time) + Braking distance

The perception-reaction time is the time it takes for a driver to see an obstacle, recognize it as a hazard, and take action to stop the vehicle. The Braking distance is the distance at which the vehicle slows down when the brakes are applied. The grade of the road is the slope of the road, which can affect the stopping distance.

The SSD is an important consideration in highway design. If the SSD is not sufficient, drivers may not be able to stop in time to avoid a collision. This can lead to accidents, injuries, and fatalities.

Here are some factors that can affect the SSD:

The speed of the vehicle
The driver's age and experience
The weather conditions
The road surface conditions
The presence of other vehicles
The presence of obstacles

Drivers should always be aware of the SSD and drive accordingly. If the SSD is not sufficient, drivers should slow down or take other precautions to avoid a collision.

PIEV theory is a model of the human reaction time in driving. It stands for Perception, Intellection, Emotion, and Volition.

Perception time is the time it takes for a driver to see an obstacle and recognize it as a hazard. This time is influenced by the driver's visual acuity, the brightness of the environment, and the distance of the obstacle.

Intellection time is the time it takes for a driver to understand the situation and decide what to do. This time is influenced by the driver's experience, the complexity of the situation, and the driver's stress level.

Emotion time is the time it takes for a driver to experience emotions in response to the situation. This time is influenced by the driver's personality, the severity of the hazard, and the driver's past experiences.

Volition time is the time it takes for a driver to take action, such as braking or steering. This time is influenced by the driver's physical condition, the type of vehicle, and the road conditions. The PIEV theory is used in highway engineering to calculate the stopping sight distance (SSD) of a road. The SSD is the distance that a vehicle can travel from the time a hazard is seen until the brakes are applied and the vehicle comes to a stop. The SSD is important because it ensures that drivers have enough time to stop safely in an emergency.

General Equation of SSD = vt+ $\frac{V^2}{2g(f \pm 0.01n)}$

If braking efficiency is considered, SSD= vt+$\frac{V^2}{2g(f \pm 0.01n)\eta}$

Where, V= design speed in m/s, t= time period of perception, n=grade

f=friction of pavement, η=braking efficiency

if design speed V is given in km/hr, then

General Equation of SSD = 0.278 x vt+ $\frac{V^2}{254(f \pm n)}$

If braking efficiency is considered, SSD= 0.278 x vt+$\frac{V^2}{254(f \pm n)\eta}$

Overtaking sight distance (OSD)

Overtaking sight distance (OSD) is the minimum distance that a driver needs to see ahead in order to safely overtake another vehicle.

It is calculated using the following formula:

OSD = d1 + d2 + d3

where:

d1 is the distance traveled by the overtaking vehicle during its reaction time

d2 is the distance traveled by the overtaking vehicle during the overtaking maneuver

d3 is the distance traveled by the oncoming vehicle during the overtaking maneuver

The reaction time is the time it takes for a driver to see a hazard, recognize it as a hazard, and take action to overtake the vehicle. The overtaking maneuver is the time it takes for the overtaking vehicle to pass the slower vehicle. The distance traveled by the oncoming vehicle is the distance that the oncoming vehicle travels during the overtaking maneuver.

The OSD is important because it ensures that drivers have enough time to safely overtake another vehicle. If the OSD is not sufficient, drivers may not be able to overtake the vehicle safely and could cause an accident.

Here are some factors that can affect the OSD:

The speed of the overtaking vehicle
The speed of the slower vehicle
The distance between the overtaking vehicle and the slower vehicle
The reaction time of the driver
The road conditions
The weather conditions

Drivers should always be aware of the OSD and drive accordingly. If the OSD is not sufficient, drivers should not attempt to overtake another vehicle.

3.5 Numerical practice on extra widening and sight distance.

Assignment I

1. Find out the total width of pavement on a horizontal curve for a new highway with a ruling minimum radius if the speed of slow moving vehicle is 80 kmph. The width of highway is 7 m and length of wheel base is 6.1 m.

2. Compute the minimum sight distance required to avoid a head on collision of two busses approaching from the opposite directions. The speed of both of the busses is   kmph. Assume a total perception and brake reaction time of 2.5 seconds. Coefficient of friction is 0.4 and brake efficiency is 50%.

3. Calculate the safe stopping distance for design speed of 60 kmph for (a) two way traffic in two lane road (b) two way traffic in a single lane road.

4. The driver of a vehicle travelling at 80 kmph up a grade required 9 m less to stop after he applies the brakes than the driver traveling at the same initial speed down the same grade. If the coefficient of friction between tire and pavement is 0.5, what is the percentage of grade and what is braking distance down the grade?

5. A vehicle moving at a speed of 90 kmph decided to overtake another slow moving vehicle. Calculate safe overtaking sight distance. Consider

a. Two lane road with two way traffic.

b. Two lane with one way traffic.

6. The speed of overtaking and overtaken vehicles are respectively 60 kmph and on a two way traffic road. If the acceleration of the overtaking vehicle is 3.6 kmphps, calculate the safe overtaking sight distance and determine the minimum length of overtaking zone.

7. Draw typical cross section in cutting and explain various components.

8. What is superelevation? Write about extra widening and write the expression for it.

9. What is OSD? Write expression for it.

10. Describe about the stopping sight distance (OSD) Write expression for

a. One way traffic in single lane.

b. Two way traffic in single lane.

Chapter 4

Highway materials

4.1 Describe Importance of soil engineering in road construction.

The soil in highway design construction is the basic ingredient that forms intermediate support for the embankment. It is used extensively for highways so that it can support the road, and all the other load heavy transportation can get distributed over the pavement design.

It helps to calculate the thickness and load-bearing capacity of the pavement on highway. By testing soil, compute moisture content, nature, permeability, and type of pavement can be constructed. It also helps to analyze the strength and avoid any kind of deformation required for highway design.

Soil engineering is a complex and challenging field, but it is essential for the construction of safe and durable roads. By understanding the properties of soil and how it behaves, soil engineers can design roads that will withstand the stresses of traffic and the elements for many years to come.

4.2 Explain Grading for road construction.

Road grading consists of using a motor grader to restore the driving surface and drainage attributes to roads. The operator will remove washboards, potholes and other irregularities by cutting the surface of the road or filling them with material moved back and forth across the road with the road grader.

Grading for road construction:

- Grading is the process of shaping the ground to create a level or sloping surface.
- In road construction, grading is used to create the roadbed, which is the foundation for the pavement.
- The goal of grading is to create a surface that is smooth, stable, and properly drained.
- The slope of the roadbed is important for drainage.
- A properly graded road will allow water to drain away from the road surface, preventing erosion and the formation of potholes.
- Compaction is the process of reducing the voids between soil particles. This makes the soil stronger and more stable.
- The soil is compacted using a variety of methods, including rollers, tampers, and vibrating plates.
- After the soil is compacted, the roadbed is ready for the construction of the pavement.
- Grading is an important part of road construction. By creating a properly graded roadbed, engineers can ensure that the road is safe, durable, and long-lasting.

4.3 Explain Sub-grade soil, its importance and requirements for practical use.

The subgrade is the layer of soil that underlies a pavement or foundation. It is the foundation of the pavement or foundation and plays a crucial role in providing support, stability, and load-bearing capacity.

The importance of subgrade soil can be summarized as follows:

- It provides the foundation for the pavement or foundation.
- It helps to distribute the loads from the pavement or foundation to the underlying soil.
- It helps to prevent the pavement or foundation from sinking or settling.
- It helps to drain water away from the pavement or foundation.
- It helps to reduce the amount of noise and vibration transmitted from the pavement or foundation.

The requirements for subgrade soil vary depending on the type of pavement or foundation being constructed. However, some general requirements include:

- The soil must be strong enough to support the loads from the pavement or foundation.
- The soil must be able to drain water away from the pavement or foundation.
- The soil must be free of organic matter and other contaminants.
- The soil must be compacted to the required density.
- The subgrade soil can be improved by adding materials such as sand, gravel, or cement. The type of material used to improve the subgrade soil will depend on the specific requirements of the project.

Here are some specific examples of the requirements for subgrade soil for different types of pavements:

For a concrete pavement, the subgrade soil should have a California Bearing Ratio (CBR) of at least 8.

For an asphalt pavement, the subgrade soil should have a CBR of at least 6.

For a granular base course, the subgrade soil should have a CBR of at least 4.

The California Bearing Ratio (CBR) is a measure of the strength of subgrade soil. A higher CBR indicates a stronger soil.

The subgrade soil is an important part of any pavement or foundation. By understanding the importance and requirements of subgrade soil, we can ensure that our pavements and foundations are safe and durable.

4.4 Define Stone aggregates, types and requirements.

Stone aggregates are granular materials that are used in construction. They are made from crushed or broken rocks, and they come in a variety of sizes and shapes. Stone aggregates are used in concrete, asphalt, mortar, and other construction materials.

The types of stone aggregates include:

Gravel: Gravel is a naturally occurring material that is composed of small, smooth stones. It is often used in road construction and in the subbase of concrete slabs.

Crushed stone: Crushed stone is made from rocks that have been crushed into smaller pieces. It is more uniform in size than gravel, and it is often used in concrete and asphalt.

Sand: Sand is a granular material that is made from small, smooth particles of rock. It is often used in concrete and mortar.

Recycled concrete aggregate: Recycled concrete aggregate is made from concrete that has been crushed and recycled. It is often used in road construction and in the subbase of concrete slabs.

Slag: Slag is a byproduct of steel production. It is a hard, angular material that is often used in concrete and asphalt.

The requirements for stone aggregates vary depending on the application. However, some general requirements include:

- The aggregates must be strong enough to support the loads that will be placed on them.
- The aggregates must be free of impurities that could weaken the concrete or asphalt.
- The aggregates must be able to drain water away from the concrete or asphalt.
- The aggregates must be compatible with the other materials that will be used in the construction project.

Stone aggregates are an important part of many construction projects. By understanding the different types of stone aggregates and their requirements, we can ensure that we use the right materials for the job.

Here are **some additional considerations** for choosing stone aggregates:

Cost: Stone aggregates can vary in cost depending on the type, size, and location.

Availability: Some types of stone aggregates may not be available in all areas.

Environmental impact: The extraction and processing of stone aggregates can have an environmental impact.

It is important to weigh all of these factors when choosing stone aggregates for a construction project.

4.5 Describe Binding materials uses and requirements.

Binding materials are used in road construction to hold the aggregate particles together and create a strong and durable surface. The most common binding materials used in road construction are:

Cement: Cement is a hydraulic binder that hardens when mixed with water. It is used to make concrete, which is the most common type of road surface.

Bitumen: Bitumen is a sticky, black material that is extracted from petroleum. It is used to make asphalt, which is another common type of road surface.

Lime: Lime is a cementitious material that is made from limestone. It is used to make lime concrete, which is sometimes used in road construction.

Tar: Tar is a sticky, black material that is made from coal or wood. It is sometimes used as a binder in road construction, but it is less common than bitumen.

The requirements for binding materials in road construction vary depending on the type of road and the climate. However, some general requirements include:

- The binding material must be strong enough to withstand the loads that will be placed on the road.
- The binding material must be durable and resistant to weathering.
- The binding material must be compatible with the other materials that will be used in the road construction.

In addition to the above, the **binding material must also be environmentally friendly and sustainable.**

The choice of binding material for road construction is a complex decision that should be made by a qualified engineer. The engineer will consider the specific requirements of the project, as well as the cost, availability, and environmental impact of the different materials.

Here are some **additional considerations for choosing binding materials** for road construction:

Cost: Binding materials can vary in cost depending on the type, quality, and location.

Availability: Some types of binding materials may not be available in all areas.

Environmental impact: The extraction and processing of binding materials can have an environmental impact.

Durability: The binding material must be durable and resistant to weathering.

Workability: The binding material must be easy to work with and apply.

It is important to weigh all of these factors when choosing binding materials for a road construction project.

Chapter 5

Highway drainage

5.1 Describe Drainage system, types and its importance.

A highway drainage system is a network of structures and channels that remove excess water from the road surface and subgrade. It is an essential component of any highway, as it helps to prevent flooding, erosion, and damage to the road structure.

There are two main types of highway drainage systems: surface drainage and subsurface drainage.

Surface drainage systems collect and remove water from the road surface. This is typically done through a system of gutters, downspouts, and storm drains. Surface drainage systems are also designed to prevent water from pooling on the road surface, which can create a hazard for drivers.

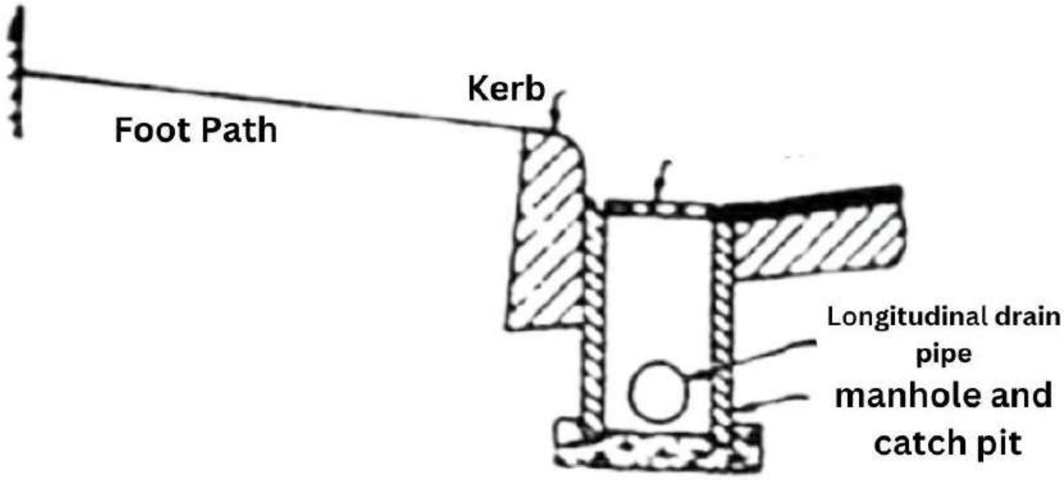

Figure 5.1 Surface drainage system in urban road (source: Khanna & Justo)

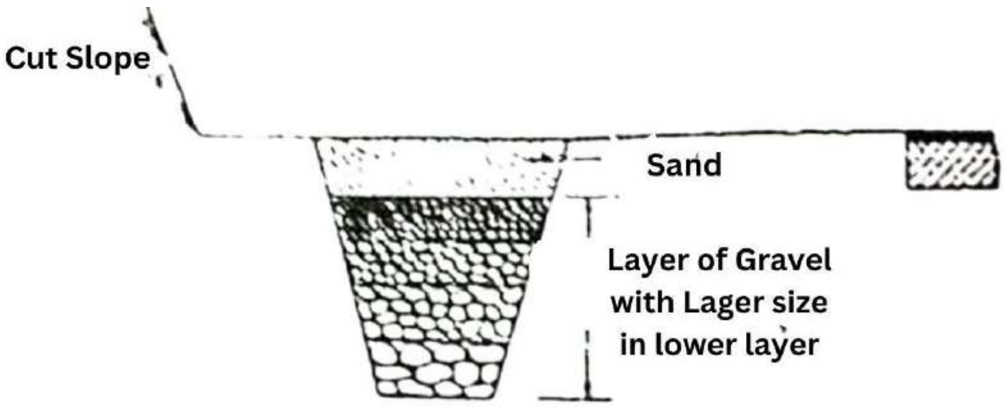

Figure 5.1 Surface drainage system in Rural Road (source: Khanna & Justo)

Subsurface drainage systems collect and remove water from the ground beneath the road surface. This is typically done through a system of perforated pipes and gravel. Subsurface drainage systems are important for preventing the roadbed from becoming saturated, which can lead to erosion and damage.

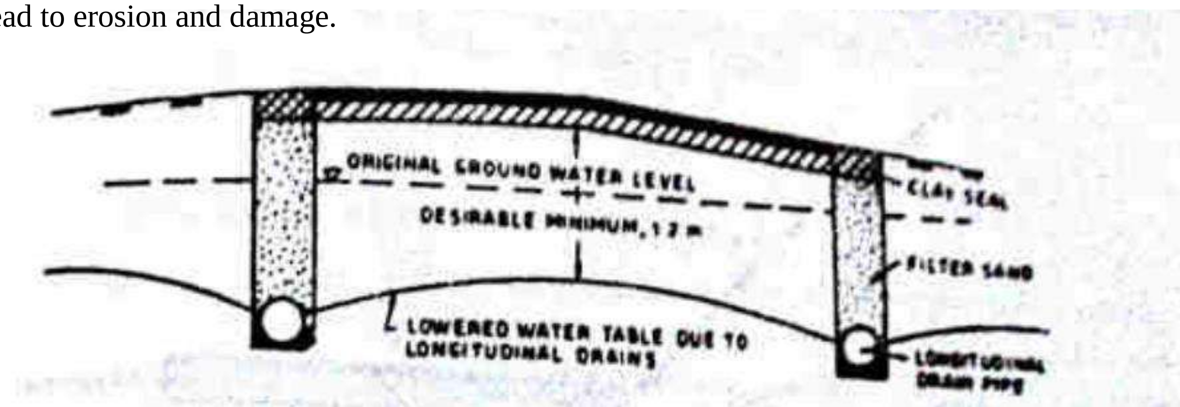

Figure 5.3 lowering the water table below the road surface using subsurface drainage system

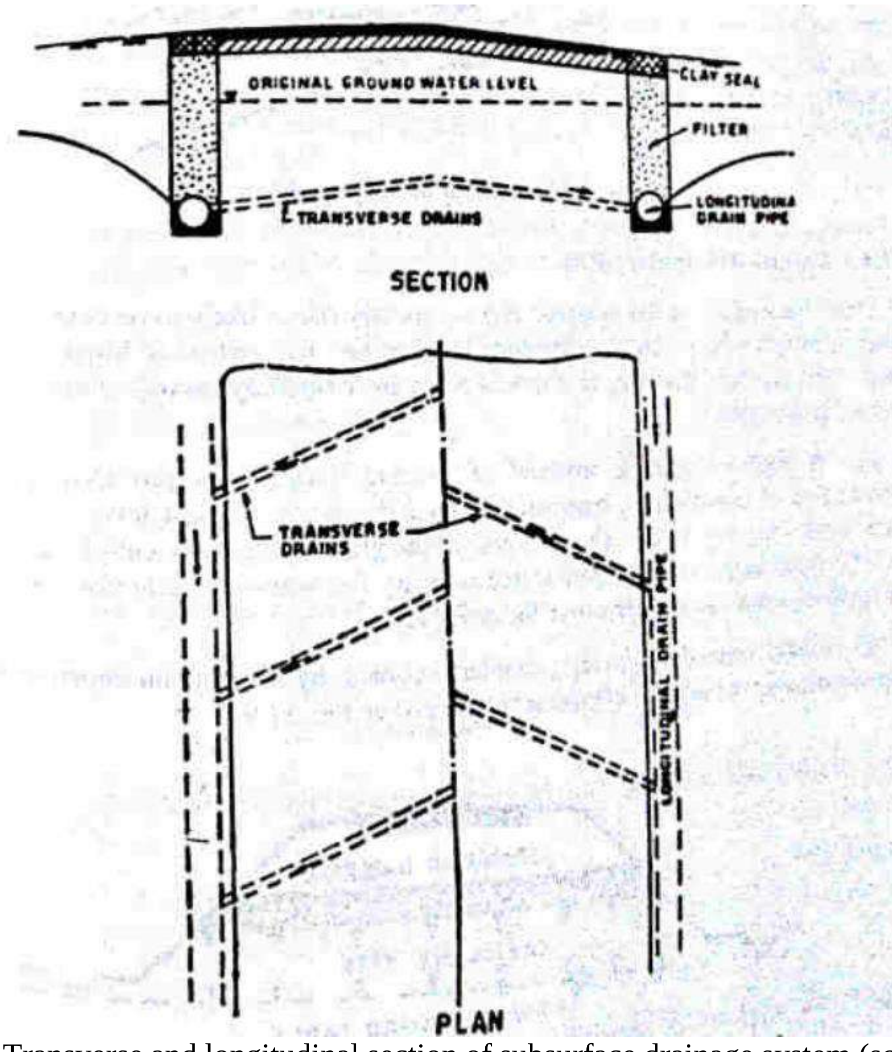

Figure 5.4 Transverse and longitudinal section of subsurface drainage system (source: Khanna & Justo)

Highway drainage systems are important for a number of reasons:

To prevent flooding: Highway drainage systems help to prevent flooding by quickly and efficiently removing water from the road surface and subgrade. This helps to keep the road safe and passable for drivers.

To prevent erosion: Highway drainage systems also help to prevent erosion by preventing water from pooling on the road surface and subgrade. This is important for protecting the road structure and preventing potholes and other damage.

To protect the road structure: Highway drainage systems help to protect the road structure by preventing water from infiltrating the subgrade. This is important for preventing the roadbed from becoming saturated, which can lead to erosion and damage.

To improve safety: Highway drainage systems help to improve safety for drivers by preventing water from pooling on the road surface. This helps to reduce the risk of hydroplaning and other accidents.

Here are some examples of highway drainage system components:

Gutters: Gutters are channels that collect and direct water away from the road surface.

Downspouts: Downspouts are vertical pipes that carry water from gutters to storm drains.

Storm drains: Storm drains are underground pipes that collect and transport water away from the road surface.

Catch basins: Catch basins are inlets to storm drains that collect water from gutters and downspouts.

Curbs: Curbs are raised edges along the sides of the road that help to prevent water from flowing onto the road surface.

Side ditches: Side ditches are channels that collect and direct water away from the road surface.

Perforated pipes: Perforated pipes are underground pipes that collect and transport water away from the subgrade.

Gravel: Gravel is used to surround perforated pipes to help filter water and remove debris.

Highway drainage systems are essential for the safety and longevity of highways. By properly designing and maintaining these systems, we can help to ensure that our roads are safe and passable for drivers.

5.2 Point out Requirements of good drainage system.

A good drainage system should meet the following requirements:

Adequate capacity: The system should be able to handle the expected amount of water runoff, even during heavy rainfall events.

Proper slope: The system should have a sufficient slope to allow water to flow freely.

Durable materials: The system should be made of durable materials that can withstand the elements and the weight of traffic.

Regular maintenance: The system should be regularly inspected and maintained to remove debris and ensure proper operation.

In addition to these general requirements, there are specific requirements for different types of drainage systems. For example, a highway drainage system must be able to handle a large volume of water and must be designed to prevent flooding. A residential drainage system, on the other hand, may be smaller and less complex.

Here are some additional requirements for a good drainage system:

Accessibility: The system should be easily accessible for inspection and maintenance.

Environmental protection: The system should be designed to minimize environmental impact, such as by preventing the discharge of pollutants into waterways.

Cost-effectiveness: The system should be cost-effective to install and maintain.

When designing and installing a drainage system, it is important to consider all of the relevant factors, including the type of property, the climate, and the local building codes. A qualified professional can help you to design and install a drainage system that meets your specific needs.

5.3 Describe Field construction procedures.

The field construction procedures of highway drainage vary depending on the type of drainage system being installed. However, there are some general steps that are common to most drainage construction projects:

Site preparation: The first step is to prepare the site for construction. This may involve clearing and grubbing the area, grading the land, and excavating for the drainage structures.

Installation of drainage structures: The next step is to install the drainage structures, such as pipes, culverts, and catch basins. These structures must be properly installed and backfilled to ensure their stability and performance.

Installation of drainage channels: Drainage channels are used to collect and direct water to the drainage structures. Channels can be made of a variety of materials, such as concrete, asphalt, or gravel.

Finishing work: Once the drainage structures and channels have been installed, the site must be restored to its original condition. This may involve grading the land, seeding the area, and repairing any damage to the surrounding landscape.

Here is a more detailed description of the field construction procedures for some common types of highway drainage systems:

Side ditches: Side ditches are open channels that run along the sides of the road to collect and direct water away from the road surface. Side ditches are typically constructed using a grader or excavator. The grader is used to create a V-shaped ditch with a smooth bottom and sides. The excavator is used to excavate the ditch to the desired depth and slope.

Storm drains: Storm drains are underground pipes that collect and transport water away from the road surface. Storm drains are typically constructed using a combination of open-cut and trenchless methods. Open-cut construction is used to excavate trenches for the pipes. Trenchless methods, such as microtunneling and directional drilling, are used to install pipes without excavating large trenches.

Culverts: Culverts are pipes or structures that are used to carry water under roads and other structures. Culverts can be made of a variety of materials, such as concrete, steel, or plastic. Culverts are typically installed using open-cut construction.

Catch basins: Catch basins are inlets to storm drains that collect water from gutters and downspouts. Catch basins are typically made of concrete and are typically constructed using open-cut construction.

Other drainage structures: Other common highway drainage structures include headwalls, endwalls, and manholes. Headwalls and endwalls are used to protect the ends of culverts and other drainage structures. Manholes are used to access underground drainage structures for inspection and maintenance.

The specific field construction procedures for highway drainage systems will vary depending on the type of system being installed and the specific site conditions. However, the general steps outlined above are common to most drainage construction projects.

It is important to note that highway drainage construction is a complex process that should be carried out by qualified professionals. Failure to properly design and install a drainage system can lead to a variety of problems, such as flooding, erosion, and damage to the road structure.

Chapter 6

Road pavement and Road making machineries with uses

6.1 Explanations on Types of pavement – Flexible and Rigid pavement definitions.

Types of Pavement: Flexible vs. Rigid

There are two main types of pavement: flexible and rigid. Each type has its own advantages and disadvantages, and the best type for a particular application depends on a variety of factors, such as traffic volume, climate, and budget.

Flexible Pavements

Definition: A flexible pavement is a layered structure that consists of a surface course (usually asphalt), a base course (often crushed stone), and a subbase course (gravel or sand).

Image of flexible pavement layers opens in a new window

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Flexible pavement layers

Characteristics:

Relatively thin (typically 6-12 inches)

Bends under load

Cracks are common

Relatively easy to repair

Less expensive than rigid pavements

Advantages:

Can be constructed quickly and easily

Adapts well to changes in the underlying soil

Smooth, comfortable ride

Relatively quiet

Disadvantages:

Requires more frequent maintenance

Susceptible to rutting and cracking

Not as durable as rigid pavements

Rigid Pavements

Definition: A rigid pavement is a single layer of concrete that is typically 8-12 inches thick.

Image of rigid pavement concrete opens in a new window

Rigid pavement concrete

Characteristics:

Rigid and strong

Does not bend under load

Cracks are less common

More expensive to repair than flexible pavements

Advantages:

Very durable

Requires less maintenance

Long lifespan

Good for heavy traffic loads

Disadvantages:

More expensive to construct

Susceptible to cracking if the underlying soil settles

Can be noisy

Rougher ride than flexible pavements

Choosing the Right Pavement Type

The best type of pavement for a particular application depends on a variety of factors, including:

Traffic volume: Rigid pavements are generally better for roads with high traffic volume, while flexible pavements are better for roads with low traffic volume.

Climate: Rigid pavements are more susceptible to damage from freezing and thawing, while flexible pavements are more susceptible to damage from heat and ultraviolet radiation.

Budget: Rigid pavements are more expensive to construct than flexible pavements.

Maintenance: Rigid pavements require less maintenance than flexible pavements.

Here are some additional factors to consider:

Local availability of materials: If a particular type of material is not readily available, the cost of transporting it to the site will need to be factored in.

Environmental impact: Both flexible and rigid pavements have an environmental impact. Flexible pavements are made from asphalt, which is a petroleum product. Rigid pavements are made from concrete, which requires the mining and processing of raw materials.

Aesthetics: Some people prefer the look of one type of pavement over the other.

Ultimately, the best way to choose the right type of pavement is to consult with a qualified engineer who can assess the specific needs of the project. Detailed study on General structures of pavement- sub-grade, sub-base, base and surface courses uses.

6.2 Detailed study on General structures of pavement- sub-grade, sub-base, base and surface courses uses.

General Structures of Pavement - Subgrade, Subbase, Base, and Surface Courses

A pavement structure is a layered system designed to support traffic loads and distribute them to the subgrade below. Each layer has a specific function and is made of different materials.

Subgrade

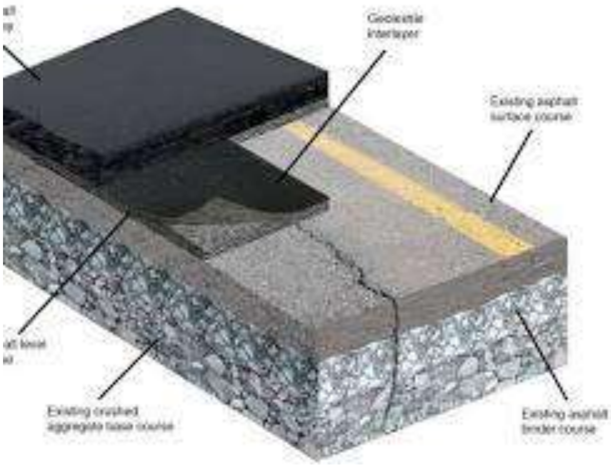
The subgrade is the natural foundation soil that supports the pavement structure. It is typically made of compacted soil, such as clay, sand, or gravel. The subgrade's primary function is to provide stability and support for the overlying layers.

Pavement Subgrade

Key characteristics of subgrade:

Strength: The subgrade must be strong enough to support the weight of the pavement and traffic loads without excessive deformation.

Drainage: The subgrade must have good drainage to prevent water from accumulating and weakening the soil.



Frost susceptibility: The subgrade should not be susceptible to frost heave, which can damage the pavement.

Subbase

The subbase is a layer of material placed on top of the subgrade. It provides a stable working platform for construction and improves drainage. The subbase is typically made of crushed stone, gravel, or recycled materials.

Pavement Subbase

Key characteristics of subbase:

Drainage: The subbase should have good drainage to prevent water from accumulating and weakening the subgrade.

Strength: The subbase should be strong enough to support the weight of the overlying layers and construction traffic.

Workability: The subbase should be stable and firm enough to provide a good working platform for construction.

Base:

The base is a structural layer that distributes traffic loads to the subbase and subgrade. It is typically made of crushed stone, asphalt concrete, or stabilized soil.

Pavement Base

Key characteristics of base:

Strength: The base must be strong enough to support the weight of the overlying layers and traffic loads without excessive deformation.

Stiffness: The base must be stiff enough to distribute traffic loads evenly to the subbase and subgrade.

Durability: The base must be durable enough to resist weathering and wear and tear.

Surface Course

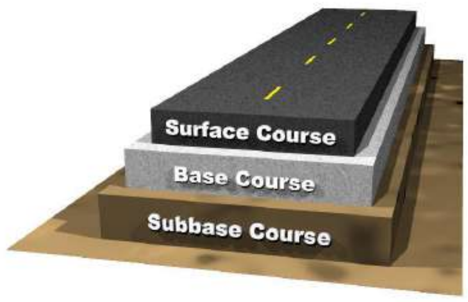
The surface course is the top layer of the pavement structure. It is the layer that is directly in contact with traffic loads. The surface course is typically made of asphalt concrete, Portland cement concrete, or other materials.

Pavement Surface Course

Key characteristics of surface course:

Friction: The surface course must provide adequate friction to prevent vehicles from skidding.

Smoothness: The surface course must be smooth to provide a comfortable ride for drivers.



Durability: The surface course must be durable enough to resist wear and tear from traffic.

Waterproofing: The surface course must be waterproof to prevent water from infiltrating the pavement structure.

Uses of Pavement Layers:

Subgrade: Provides stability and support for the overlying layers.

Subbase: Provides a stable working platform for construction, improves drainage, and protects the subgrade from frost heave.

Base: Distributes traffic loads to the subbase and subgrade, provides strength and stiffness, and resists wear and tear.

Surface course: Provides friction for traction, smoothness for a comfortable ride, durability to resist wear and tear, and waterproofing to protect the pavement structure.

Conclusion:

The subgrade, subbase, base, and surface course are all important components of a pavement structure. Each layer has a specific function and is made of different materials. By understanding the function and properties of each layer, engineers can design and construct pavements that are safe, durable, and long-lasting.

6.3 Measure Role of labor vs machinery in road construction.

Both labor and machinery play crucial roles in road construction, but their impact varies depending on the specific project, available resources, and local context. Here's a comparison of their roles and relative importance:

Labor:

Roles:

Earthworks: Excavation, embankment construction, grading, and shaping the roadbed.

Material handling: Loading and unloading materials like aggregates, asphalt, and concrete.

Pavement construction: Placing, spreading, and compacting base, subbase, and surface courses.

Other tasks: Drainage installation, retaining wall construction, landscaping, and traffic management.

Importance:

Labor-intensive: Provides employment opportunities, especially in developing countries.

Flexibility: Adapts to complex terrain and conditions where large machinery is impractical.

Quality control: Allows for close supervision and attention to detail in critical tasks.

Cost-effective: Can be cheaper than machinery in small-scale or remote projects.

Challenges:

Physical demands: Requires manual labor, which can be strenuous and lead to fatigue and injuries.

Slow construction: Can be slower than machine-based methods, especially for large projects.

Skill dependence: Requires skilled and experienced workers to ensure quality construction.

Weather dependence: Can be affected by weather conditions, leading to delays and disruptions.

Machinery:

Roles:

Earthmoving: Large-scale excavation, hauling, and filling operations.

Material handling: Efficient loading, unloading, and transporting large quantities of materials.

Paving: Automated paving machines for asphalt and concrete surfaces.

Compaction: Heavy rollers for efficient and consistent compaction of pavement layers.

Importance:

Efficiency: Saves time and labor, leading to faster construction times.

Large-scale projects: Handles large volumes of materials and earthworks efficiently.

Reduced labor demands: Less reliance on manual labor, reducing potential for injuries and fatigue.

Improved quality: Automated equipment can achieve consistent and high-quality construction.

Challenges:

High cost: Initial investment in machinery is expensive, making it less suitable for small projects.

Limited flexibility: May not be suitable for complex terrain or tight spaces where manual labor is more adaptable.

Maintenance and fuel: Requires regular maintenance and fuel, adding to operational costs.

Skill requirements: Skilled operators are needed for efficient and safe use of machinery

Measuring the role of each factor depends on several variables:

Project size and complexity: Larger projects often benefit from machinery, while smaller projects or those requiring detailed work may rely more heavily on labor.

Terrain and accessibility: Difficult terrain may require labor-intensive methods, while accessible areas can be more efficient with machinery.

Available resources: Access to skilled workers and appropriate machinery influences the choice between labor and machine-based approaches.

Local context: Labor-intensive methods may be preferred in situations where employment opportunities are a priority, while machinery may be more suitable in areas with limited labor availability.

Budget: The cost of labor and machinery needs to be considered within the overall project budget.

Conclusion:

Both labor and machinery play vital roles in road construction. The optimal approach depends on the specific project context, considering factors like project size, terrain, available resources, and local priorities. Striking a balance between labor and machinery can ensure efficient, high-quality, and sustainable road construction.

6.4 Explain Earthwork machinery types and uses.

Earthwork machinery is a crucial component of any construction project, responsible for excavating, moving, and shaping the earth to create the foundation for buildings, roads, and other structures. Different types of earthwork machinery are used for specific tasks depending on the project's needs and the characteristics of the soil. Here are some of the most common types of earthwork machinery and their uses:

1. Excavators:

Excavators are versatile machines used for digging trenches, foundations, pits, and other excavations. They have a long arm with a bucket or attachment at the end that can scoop, lift, and dump soil and other materials. Excavators come in various sizes, from small mini-excavators to large hydraulic excavators capable of moving massive amounts of earth.

Uses:

- Excavating trenches for foundations, pipelines, and utilities
- Digging pits for pools, ponds, and other structures
- Loading and unloading trucks with soil, gravel, and other materials
- Demolition of old buildings and structures

2. Bulldozers:

Bulldozers are powerful machines with large blades used for pushing and grading soil. They are ideal for large-scale earthmoving projects, such as clearing land, building roads, and creating embankments. Bulldozers come in various sizes and types, including crawler bulldozers with tracks for better traction and wheeled bulldozers for faster travel speeds.

Uses:

- Clearing land for construction projects
- Grading and leveling land for roads, parking lots, and other surfaces
- Pushing large amounts of soil, sand, and gravel
- Creating embankments and dams

3. Motor Graders:

Motor graders are equipped with a long blade that can be adjusted to different angles for precise grading and leveling of soil. They are often used to finish the surface of roads, parking lots, and other flat areas after initial grading with a bulldozer.

Uses:

- Fine grading and leveling of soil surfaces
- Shaping and sloping roads and embankments
- Spreading gravel and asphalt
- Maintaining existing roads and parking lots

4. Loaders:

Loaders are used for scooping, lifting, and transporting materials like soil, gravel, sand, and debris. They come in various types, including wheel loaders with large buckets and front-end loaders mounted on tractors.

Uses:

- Loading trucks with soil, gravel, and other materials
- Clearing debris from construction sites
- Stockpiling materials for later use
- Feeding material into crushers and other equipment

5. Dump Trucks:

Dump trucks are essential for transporting large quantities of excavated soil, gravel, and other materials from the excavation site to another location. They come in various sizes and configurations, with different capacities and unloading mechanisms.

Uses:

- Hauling excavated soil, gravel, and other materials
- Delivering materials to construction sites
- Removing debris from excavation and demolition projects
- Transporting materials for landscaping and other projects

6. Compactors:

Compactors are used to consolidate and compress soil, improving its stability and preventing settlement. They come in various types, including vibratory rollers, pneumatic rollers, and pad foot rollers.

Uses:

- Compacting soil after excavation and backfilling
- Creating a stable foundation for roads, buildings, and other structures
- Preventing soil erosion and settlement
- Improving the performance of asphalt and concrete pavements

7. Scrapers:

Scrapers are used for large-scale earthmoving projects, such as digging and transporting large quantities of soil over long distances. They have a large bowl that can be filled with soil and then towed to a dump site.

Uses:

- Excavating large quantities of soil for construction projects
- Building embankments and dams

Creating level surfaces for roads and airports

- Removing overburden and waste materials from mines and quarries

8. Trencher:

Trenchers are specialized machines used for digging narrow trenches for pipelines, cables, and other utilities. They have a chain or wheel fitted with teeth that cut through the soil and remove it from the trench.

Uses:

- Digging trenches for pipelines, cables, and utilities
- Installing drainage pipes and irrigation systems
- Laying fiber optic cables and other communication lines
- Preparing trenches for foundation walls

6.5 Describe Compaction equipment- Three wheeled road roller, Sheep foot rollers, Pneumatic tired roller, Vibratory rollers.

Compaction is a crucial step in various construction projects, from building roads and pavements to creating foundations and embankments. It improves the soil's strength, stability, and durability by reducing air voids and increasing density. Different types of compaction equipment are used depending on the soil type, project requirements, and desired results. Here's a closer look at four common types of compaction equipment:

1. Three-Wheeled Road Roller:

These are relatively small and lightweight rollers, typically used for compacting asphalt and other paved surfaces. They have three steel wheels arranged in a triangular pattern, providing good coverage and maneuverability.

Uses:

- Compacting asphalt and concrete pavements
- Patching and repairing roads
- Compacting soil in trenches and other confined areas
- Ideal for small-scale projects and finishing work

2. Sheepfoot Roller:

These rollers have a steel drum covered with numerous protruding "feet" or "lugs" that exert pressure on the soil, creating a kneading effect. They are particularly effective for compacting cohesive soils like clays and silts.

Uses:

- Compacting clay soils for embankments, dams, and foundations
- Stabilizing subgrades for roads and pavements
- Increasing the shear strength of cohesive soils

3. Pneumatic Tired Roller:

These rollers use large, inflated tires to provide a kneading and rolling action, ideal for compacting granular soils like sand and gravel. Their wide tires offer good coverage and help to smooth the surface.

Uses:

- Compacting granular soils for subbases and road bases
- Finishing and smoothing asphalt and concrete surfaces
- Providing uniform compaction over large areas

4. Vibratory Rollers:

These rollers use vibratory motors to apply dynamic force to the soil, increasing the effectiveness of compaction. They come in various sizes and types, including smooth drum vibratory rollers and padfoot vibratory rollers, offering versatility for different soil conditions.

Uses:

- Compacting a wide range of soil types, including sands, gravels, clays, and silts
- Achieving high levels of compaction in a shorter amount of time
- Working in confined areas where large rollers are not suitable
- Ideal for large-scale projects requiring efficient and consistent compaction

6.6 Illustrate transporting equipment's and watering equipment.

Introduction:

In highway construction and maintenance, efficient and safe transportation of equipment is crucial for project success. Similarly, proper watering equipment plays a vital role in dust control, compaction, and vegetation establishment. This lecture explores the various types of equipment used for these purposes, highlighting safe practices and key considerations.

<u>Transporting Equipment:</u>

Types of Equipment:

Heavy Machinery: Excavators, graders, pavers, dump trucks, rollers, etc.

Support Vehicles: Cranes, forklifts, fuel trucks, water trucks, etc.

Personal Vehicles: Cars, trucks, vans for personnel transportation.

<u>Transportation Methods:</u>

Flatbed Trucks: Suitable for larger machinery, secured with chains and straps.

Lowboy Trailers: Accommodate heavy equipment with low clearance.

Trailers: For smaller equipment and support vehicles.

Towing: For disabled or oversized equipment.

<u>Safety Considerations:</u>

Permits and Regulations: Ensure compliance with weight and dimension restrictions.

Vehicle Maintenance: Regular inspections and servicing to prevent breakdowns.

***Secure Loading and Unloading*:** Proper use of chains, straps, and blocking material.

Roadworthiness: Check brakes, lights, and tires before travel.

Traffic Awareness: Maintain safe following distances and signal clearly.

Personal Protective Equipment (PPE): High-visibility clothing, hard hats, safety glasses, etc.

<u>Watering Equipment:</u>

Types of Equipment:

Water Trucks: Deliver water for dust control, compaction, and landscaping.

Sprinkler Systems: Fixed or mobile systems for watering vegetation and landscaped areas.

Portable Tanks and Pumps: Provide water for smaller tasks and remote locations.

Hand Watering Equipment: Watering cans and hoses for targeted watering.

Applications:

***Dust Control*:** Suppress dust generated by construction activities.

Compaction: Aid in proper compaction of base and asphalt layers.

Vegetation Establishment: Irrigate newly planted landscaping and roadside vegetation.

***Erosion Control**:* Minimize soil erosion on slopes and embankments.

<u>Water Conservation:</u>

Use efficient equipment: Choose systems with low water consumption rates.

Targeted watering: Avoid over spraying by using nozzles and sprinkler control valves.

Monitor conditions: Adjust watering frequency based on weather and soil moisture.

Reclaimed water: Consider using treated wastewater for non-potable applications.

6.7 Explain Rock excavation machinery.

Rock excavation is a crucial step in highway construction, often involving the removal of solid rock formations to make way for the roadbed. This process necessitates the use of specialized machinery that can efficiently and safely break up and remove the rock.

Here's a breakdown of some common rock excavation machinery used in highway engineering:

1. Rippers:

- Powerful, tractor-mounted implements with heavy-duty shanks that tear and fracture the rock.
- Ideal for ripping soft to medium-hard rock formations.
- Can be equipped with single or multiple shanks depending on the rock's hardness and the required excavation depth.

2. Hydraulic Hammers:

- Heavy-duty attachments mounted on excavators or backhoes.
- Utilize a piston to deliver high-impact blows that break apart the rock.
- Effective for breaking hard and fractured rock formations.

3. Blasting:

- Explosives are strategically placed and detonated to fragment the rock.
- Used for large-scale excavations or extremely hard rock formations.
- Requires careful planning and execution due to safety concerns and environmental considerations.

4. Rock Drills:

- Rotary or percussive drills used to create holes in the rock for blasting or bolting.
- Allow for controlled blasting and precise rock removal.

5. Excavators:

- Versatile earth-moving equipment equipped with buckets or attachments to load and remove the broken rock.
- Essential for clearing away excavated rock and preparing the ground for further construction.

6. Loaders:

- Front-end loaders or wheel loaders used to scoop up and transport the excavated rock.
- Ensure efficient removal of rock debris from the excavation site.

7. Haul Trucks:

- Heavy-duty trucks used to transport the excavated rock to disposal sites or processing facilities.
- Crucial for maintaining a smooth flow of material and minimizing disruption at the excavation site.

Choosing the Right Machinery:

The selection of rock excavation machinery depends on various factors, including:

Rock type and hardness: Different machinery is suited for different rock types and their hardness levels.

Excavation depth and size: The machinery's capacity and reach should match the project's requirements.

Safety considerations: The chosen machinery must comply with safety regulations and minimize risks to workers.

Environmental impact: Some machinery has a lower environmental impact than others, which might be a deciding factor.

6.8 Describe Production of aggregates.

Aggregates are the primary component of pavement and highway construction, constituting roughly 95% of asphalt mixes and a significant portion of concrete mixes. Their quality and production directly impact the performance and durability of our roads.

Understanding Aggregates:

Aggregates are naturally occurring or crushed granular materials like sand, gravel, and crushed rock. They are classified based on size, with coarse aggregates exceeding 4.75mm and fine aggregates smaller than 4.75mm.

Aggregate Production Process:

1. ***Extraction:***

Quarrying: Explosives or mechanical methods like crushers and excavators extract rock from quarries.

Mining: Sand and gravel are often mined from riverbeds, pits, or beaches.

2. **Crushing and Screening:**

Primary Crushing: Jaw crushers or cone crushers break down large rocks into smaller pieces.

Secondary and Tertiary Crushing: Further reduce the size and create specific aggregate gradations using hammer mills or impact crushers.

Screening: Vibrating screens separate aggregates into different sizes according to desired specifications.

3. **Washing and Stockpiling:**

Washing: Removes impurities like clay and dust through water jets or scrubbers.

Stockpiling: Aggregates are segregated and stored in piles categorized by size and type.

4. **Transportation:**

Trucks: Haul aggregates from the production site to asphalt plants, concrete batching plants, or directly to construction sites.

Conveyors: Used for efficient movement of aggregates within processing facilities or stockpiles.

Quality Control:

Throughout the production process, strict quality control measures ensure aggregates meet specific standards for strength, durability, cleanliness, and gradation. Tests like Los Angeles Abrasion Test, Soundness Test, and Sieve Analysis evaluate these properties.

Environmental Considerations:

Aggregate production can have environmental impacts like dust generation, noise pollution, and water usage. Responsible practices like dust control measures, proper water management, and minimizing waste generation are crucial.

Importance of Aggregate Production:

High-quality and sustainable aggregate production forms the backbone of robust and long-lasting highways. Understanding the process and its impact helps ensure efficient infrastructure development while minimizing environmental consequences.

Chapter 7

Road Construction Technology

7.1 Describe Embankment construction.

Embankments are raised sections of earth or rock created to elevate the roadway above the natural ground level. They are crucial components of highways, especially when traversing valleys, low-lying areas, or uneven terrain.

Key Functions of Embankments:

- Provide a stable and level surface for the roadbed and pavement.
- Improve drainage and prevent waterlogging.
- Reduce excavation requirements in hilly areas.
- Improve visibility and safety for drivers.
- Create aesthetically pleasing landscapes along the highway.

Embankment Construction Process:

1. ***Site Preparation:***

- Clear vegetation and topsoil from the designated area.
- Strip and stockpile fertile topsoil for later landscaping.
- Grade the subgrade to a smooth and firm base.

2. ***Material Transportation and Placement:***

- Identify suitable borrow sources for embankment material like soil, rock, or a combination.
- Load and transport the material to the embankment site using dump trucks, conveyors, or other equipment.
- Spread the material in layers, typically 150-300mm thick, ensuring proper compaction with each layer.

3. ***Compaction:***

- Compaction is crucial for achieving optimal density, stability, and bearing capacity of the embankment.
- Different compaction equipment like vibratory rollers, sheepsfoot rollers, and pneumatic rollers are used depending on the material and layer thickness.
- Compaction tests are conducted regularly to ensure proper density is achieved throughout the embankment.

4. ***Drainage Measures:***

- Proper drainage is essential to prevent waterlogging and erosion.
- Ditches, swales, and drainage pipes are installed alongside and within the embankment to channel water away from the roadbed.
- Geotextiles can be used to separate embankment materials and prevent erosion at the interface with the subgrade.

5. ***Finishing and Protection:***

- The final layer of the embankment is often finished with topsoil and vegetation to promote erosion control and improve aesthetics.
- Slope stabilization measures like retaining walls or gabions might be necessary for steeper slopes.

Embankment Design Considerations:

- ***Geotechnical properties of the fill material:*** Strength, compressibility, and drainage characteristics must be assessed.
- ***Height and slope of the embankment:*** Stability analysis is conducted to determine safe slopes and prevent landslides.
- ***Settlement:*** Embankments settle over time, so design accounts for this potential movement.
- ***Environmental impact:*** Minimize disturbance to natural habitats and waterways during construction.

7.2 Describe earthen road construction.

Earthen roads, while not as sophisticated as their paved counterparts, play a crucial role in rural areas and remote regions, providing vital transportation access. Understanding their construction principles is essential for highway engineers.

Planning and Design:

Route Selection: Carefully consider factors like terrain, drainage, traffic volume, and environmental impact when choosing the path.

Geometric Design: Determine appropriate lane width, shoulder design, and cross-section based on anticipated traffic and safety requirements.

Drainage Design: Proper drainage is crucial to prevent erosion and ensure road stability. Ditches, culverts, and other drainage structures should be carefully planned and integrated.

Construction Stages:

Clearing and Grubbing: Vegetation and topsoil are removed from the roadbed to create a stable base.

Excavation and Embankment: Earth is cut from hills or excavated from borrow pits to fill low areas and create the desired road elevation.

Grading and Shaping: The roadbed is leveled and shaped using graders and bulldozers to achieve the desired cross-section and drainage characteristics.

Compaction: The soil is compacted thoroughly using rollers to increase its density, stability, and bearing capacity.

Surfacing: Depending on traffic volume and weather conditions, a simple gravel or sand surfacing might be applied for improved ride ability and dust control.

Material Considerations:

Soil Type: Choosing the right soil type for the subgrade and embankment is crucial for stability and drainage. Clayey soils, for example, can be problematic due to their poor drainage and susceptibility to erosion.

Moisture Content: Maintaining optimal moisture content during compaction is essential for achieving proper density and preventing future cracking or rutting.

Maintenance and Rehabilitation:

- Regular grading and drainage maintenance are crucial to prevent erosion and maintain proper road surface drainage.
- Dust control measures like watering or applying dust palliatives might be necessary on heavily trafficked roads.
- Over time, earthen roads might require resurfacing or rehabilitation depending on their condition and traffic volume.

Advantages of Earthen Roads:

- Lower construction costs: Compared to paved roads, earthen roads require significantly less investment in materials and construction equipment.
- Environmentally friendly: Earthen roads have a smaller environmental footprint than paved roads due to reduced use of resources and minimal excavation waste.
- Suitable for remote areas: Earthen roads can be constructed in challenging terrains and remote regions where access to heavy machinery and materials for paved roads might be limited.

Disadvantages of Earthen Roads:

Lower traffic capacity: Earthen roads are typically less durable and have lower weight-bearing capacity than paved roads, limiting their suitability for heavy traffic.

Susceptibility to weather: They are more prone to damage from heavy rainfall, flooding, and extreme temperatures, requiring frequent maintenance.

Dust generation: Unpaved surfaces generate significant dust, impacting air quality and visibility, especially in dry conditions.

7.3 Describe Gravel road construction.

Gravel roads play a vital role in rural areas and remote regions, providing vital transportation access despite being less sophisticated than their paved counterparts. Understanding their construction principles is crucial for highway engineers.

Planning and Design:

Route Selection: Carefully consider factors like terrain, drainage, traffic volume, and environmental impact when choosing the path.

Geometric Design: Determine appropriate lane width, shoulder design, and cross-section based on anticipated traffic and safety requirements.

Drainage Design: Proper drainage is crucial to prevent erosion and ensure road stability. Ditches, culverts, and other drainage structures should be carefully planned and integrated.

Construction Stages:

Clearing and Grubbing: Vegetation and topsoil are removed from the roadbed to create a stable base.

Excavation and Embankment: Earth is cut from hills or excavated from borrow pits to fill low areas and create the desired road elevation.

Grading and Shaping: The roadbed is leveled and shaped using graders and bulldozers to achieve the desired cross-section and drainage characteristics.

Compaction: The soil is compacted thoroughly using rollers to increase its density, stability, and bearing capacity.

Surfacing: A layer of gravel is applied to the compacted subgrade. The gravel thickness and type vary depending on traffic volume, anticipated weather conditions, and budget constraints.

Material Considerations:

Gravel Type: Choosing the right gravel type is crucial for performance and durability. Crushed rock is generally preferred for its strength and angularity, while rounded river gravels can be used for lighter traffic roads.

Gravel Size: The appropriate gravel size depends on the desired surface characteristics. Larger stones provide better stability and drainage, while smaller stones create a smoother driving surface.

Geotextiles: In some cases, geotextiles are placed between the subgrade and gravel layer to improve separation, prevent soil erosion, and enhance drainage.

Maintenance and Rehabilitation:

- Regular grading and drainage maintenance are crucial to prevent erosion and maintain proper road surface drainage.
- Dust control measures like watering or applying dust palliatives might be necessary on heavily trafficked roads.
- Over time, gravel roads might require resurfacing with additional gravel, especially in areas with high traffic volume or harsh weather conditions.

Advantages of Gravel Roads:

Lower Construction Costs: Compared to paved roads, gravel roads require significantly less investment in materials and construction equipment.

Environmentally Friendly: Gravel roads have a smaller environmental footprint than paved roads due to reduced use of resources and minimal excavation waste.

Suitable for Remote Areas: Gravel roads can be constructed in challenging terrains and remote regions where access to heavy machinery and materials for paved roads might be limited.

Disadvantages of Gravel Roads:

Lower Traffic Capacity: Gravel roads are typically less durable and have lower weight-bearing capacity than paved roads, limiting their suitability for heavy traffic.

Susceptibility to Weather: They are more prone to damage from heavy rainfall, flooding, and extreme temperatures, requiring frequent maintenance.

Dust Generation: Unpaved surfaces generate significant dust, impacting air quality and visibility, especially in dry conditions.

7.4 Describe WBM road construction.

WBM, or Water Bound Macadam, is a type of road construction commonly used in rural and low-traffic areas. It's a cost-effective and relatively simple method of building a durable and long-lasting road surface using crushed stone aggregates.

Why choose WBM?

Lower construction costs: Compared to asphalt or concrete roads, WBM requires less expensive materials and simpler construction techniques.

Sustainability: WBM uses locally available materials and can be easily repaired or resurfaced with minimal environmental impact.

Durability: Properly constructed WBM roads can withstand moderate traffic and weather conditions for many years.

Suitable for remote areas: WBM construction is less reliant on heavy machinery and specialized equipment, making it accessible in remote locations.

Construction Stages:

Preparation:

Clearing and Grubbing: Vegetation and topsoil are removed from the roadbed to create a stable base.

Grading and Shaping: The roadbed is leveled and shaped to achieve the desired cross-section and drainage characteristics.

Drainage System: Ditches and culverts are installed to ensure proper drainage and prevent waterlogging.

Foundation Course:

- A layer of coarse crushed stone aggregates (typically 60-100mm size) is spread evenly on the prepared bed.
- The stones are manually leveled and compacted with mechanical rollers.
- Water is applied during compaction to aid binding and filling voids between the stones.

Blind Layer:

- A smaller size of crushed stone aggregates (typically 40-60mm) is spread over the compacted foundation course.
- Similar to the foundation course, the blind layer is leveled, compacted, and watered.

Surface Layer:

The final layer consists of even smaller crushed stone aggregates (typically 20-40mm) known as screenings.

- This layer is meticulously spread, leveled, and compacted to create a smooth and even surface.
- Water binding and mechanical rolling are crucial for a strong and durable surface.

Finishing Touches:

- Shoulders are constructed on either side of the road for stability and drainage.
- Traffic signs and markings are installed for safety and guidance.

Maintenance and Rehabilitation:

- Regular inspection and maintenance are crucial for maintaining WBM roads. This includes patching potholes, filling ruts, and reapplying screenings as needed.
- Over time, the surface might require resurfacing with new layers of stone aggregates.

Advantages and Disadvantages of WBM Roads:

Advantages:

- Lower construction and maintenance costs
- Sustainable and environmentally friendly

- Durable and long-lasting
- Suitable for remote locations and low-traffic areas

Disadvantages:

- Rougher riding surface compared to paved roads
- Dust generation can be an issue in dry climates
- Not suitable for heavy traffic loads
- Requires regular maintenance

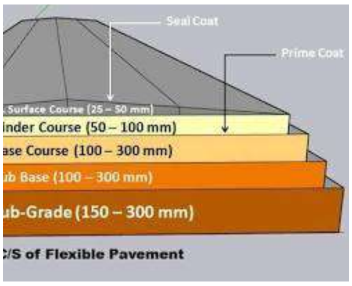
7.5 Describe bituminous road construction.

Bituminous roads, commonly known as asphalt roads, are the workhorse of modern highways. Their durability, flexibility, and relatively low cost make them the dominant choice for high-traffic roads worldwide. Understanding their construction process is crucial for highway engineers.

Components of a Bituminous Road:

A typical bituminous road consists of several layers:

Subgrade: The natural soil foundation that supports the entire road structure. Proper compaction and drainage of the subgrade are essential for long-term road performance.



Subbase: A layer of granular material like gravel or crushed rock placed above the subgrade to improve drainage and provide additional bearing capacity.

Base Course: A thicker layer of asphalt concrete or crushed rock that distributes traffic loads and provides structural support.

Binder Course: A thin layer of hot-mix asphalt that binds the base course to the surface course and provides some waterproofing.

Surface Course: The topmost wearing layer of hot-mix asphalt directly exposed to traffic. It needs to be resistant to wear and tear, provide good skid resistance, and offer smooth driving conditions.

Construction Process:

Site Preparation: The site is cleared, leveled, and graded according to the designed road geometry. Drainage structures like ditches and culverts are installed.

Subgrade and Subbase Construction: The subgrade is compacted to achieve the desired density and strength. The subbase material is then placed and compacted in layers.

Paving: Asphalt concrete for the base course, binder course, and surface course is prepared at asphalt plants and transported to the site in hot trucks. Each layer is spread using pavers and then compacted to achieve the required density and surface smoothness.

Jointing and Sealing: Joints between paving sections are treated with hot-poured joint sealant to prevent water infiltration and cracks.

Curing and Marking: The asphalt pavement is allowed to cool and cure before traffic is allowed. Finally, lane markings and signage are installed.

Types of Bituminous Pavements:

Hot-Mix Asphalt (HMA): The most common type, using heated asphalt binder mixed with aggregates. Offers superior performance and durability.

Warm-Mix Asphalt (WMA): Similar to HMA but uses additives to lower mixing temperatures, reducing energy consumption and emissions.

Cold-Mix Asphalt (CMA): Pre-mixed asphalt used for patching or temporary repairs, requiring no heating.

Advantages of Bituminous Roads:

Durable and long-lasting: Can withstand high traffic volumes for many years with proper maintenance.

Smooth and comfortable driving experience: Provides a quieter and smoother ride compared to concrete roads.

Flexible: Can adapt to minor ground movements and settlements without cracking.

Relatively quick construction: Paving can be completed quickly compared to concrete roads.

Recyclable: Up to 25% of reclaimed asphalt pavement can be used in new mixes, reducing waste and cost.

Disadvantages of Bituminous Roads:

Susceptible to temperature extremes: Can become soft and rutting in hot weather or crack in cold weather.

Higher maintenance costs: Require regular crack sealing and surface repairs compared to concrete roads.

Environmental concerns: Asphalt production and heating can generate emissions and air pollution.

7.6 Describe Surface dressing, Otta seal.

Surface dressing, also known as chip seal, is a cost-effective way to maintain and improve the surface of low-volume roads and walkways. It involves applying a thin layer of bitumen binder (a sticky, tar-like substance) to a clean, dry surface, followed by a layer of stone chippings.

Construction process:

Preparation: The existing road surface is thoroughly cleaned and any loose debris removed.

Binder application: A thin layer of bitumen binder is sprayed onto the prepared surface. This acts as a glue to hold the chippings in place.

Chipping application: A layer of small, consistently sized stone chippings is spread over the wet binder. It's important to use the right size and type of chippings for the specific application.

Rolling: The chippings are pressed into the binder using a roller, ensuring they are firmly embedded.

Excess removal: Once the binder cools and sets, excess chippings are swept away.

Traffic consolidation: As vehicles drive over the newly dressed surface, they help further embed the chippings into the binder, completing the process.

Benefits of Surface Dressing:

Cost-effective: Compared to complete repaving, surface dressing is significantly cheaper, making it a good option for budget-conscious projects.

Quick and easy application: The process is relatively simple and can be completed quickly, minimizing road closures and disruption.

Improved safety: By creating a textured surface, surface dressing enhances skid resistance, improving road safety for both drivers and pedestrians.

Waterproofing: The binder seals the road surface, preventing water infiltration and protecting the underlying layers from damage.

Extends lifespan: Surface dressing can effectively extend the life of a road by several years, delaying the need for more expensive repairs or complete reconstruction.

Otta seal

The Otta seal is a type of surface dressing that is similar to single-sized chip seal, but it uses a graded aggregate that contains all sizes of particles, from fines to coarse chips. This gives the Otta seal a smoother and more durable surface than chip seal. It's named after the town of Otta in Norway, where it was first developed in the 1960s.

The Process:

Preparation: The existing road surface is cleaned and graded to create a smooth, even base. Cracks and potholes are repaired to ensure a stable foundation.

Binder application: A thick layer of soft bitumen emulsion (typically cutback asphalt or emulsified asphalt) is sprayed onto the prepared surface. The amount of binder used is crucial and depends on factors like aggregate size, gradation, and desired surface texture.

Aggregate application: A single layer of graded aggregate (containing a mix of particle sizes, from fines to coarse chips) is evenly spread over the wet binder. The specific gradation varies based on project requirements and traffic volume.

Rolling: The aggregate is compacted into the binder using a steel-wheeled roller. This ensures proper embedment and creates a smooth, uniform surface. Rolling is done in multiple passes, gradually increasing the pressure to achieve optimal density.

Curing: The Otta seal is left to cure and set for several hours or days, allowing the binder to fully adhere to the aggregate. Traffic may be restricted during this period.

Finishing: Once cured, any excess loose aggregate is swept away, leaving a clean and finished surface.

Advantages of Otta seal:

Durable: Offers better durability than traditional chip seal, especially in harsh climates and under moderate to heavy traffic.

Cost-effective: While more expensive than chip seal upfront, its longer lifespan and lower maintenance needs can make it cost-effective in the long run.

Versatile: Can be adapted to various traffic volumes and climatic conditions by adjusting binder type, aggregate gradation, and construction techniques.

Smooth surface: Provides a smoother and more comfortable driving experience compared to chip seal.

Easy maintenance: Relatively easy to maintain with periodic sweeping and occasional resealing when needed.

Applications:

Otta seal is commonly used on:

Low- to medium-volume roads: Rural roads, secondary roads, and access roads.

Gravel roads: Can be used to upgrade and seal existing gravel roads.

Unpaved areas: Parking lots, driveways, and other unpaved surfaces.

Which is better, surface dressing or Otta seal?

The best choice for a particular project will depend on a number of factors, including the traffic volume, the type of aggregate, and the budget. Surface dressing is typically less expensive than Otta seal, but it may not be as durable. Otta seal is more durable than surface dressing, but it may not be suitable for high-volume roads.

7.7 Rigid pavement construction procedures.

Rigid pavement construction, typically using concrete as the surface layer, involves several crucial steps to ensure longevity and performance. Here's a breakdown of the key procedures:

1. Subgrade Preparation:

Clearing and Grading: This involves removing vegetation, debris, and topsoil to the required depth. The subgrade is then shaped and graded to meet the design specifications for slope and elevation.

Compaction: The subgrade is compacted rigorously using specialized machinery to achieve a uniform and consistent density. This is crucial for preventing future settlement and cracking of the pavement.

Proof Rolling: Sometimes, a loaded truck is driven over the compacted subgrade to identify any weak spots that require further compaction.

2. Base Course Construction (Optional):

Placement: If required by the design, a granular base course (e.g., crushed stone) is laid over the prepared subgrade. This layer provides additional drainage, load distribution, and frost protection.

Compaction: Similar to the subgrade, the base course is also compacted thoroughly to ensure uniform density and support.

3. Jointing and Doweling:

Contraction Joints: These joints are placed at regular intervals to control cracking caused by shrinkage and thermal expansion. Different types of joints, such as sawed joints, precast panels, or dowel and contraction joint (DCJ) systems, can be used.

Expansion Joints: These wider joints are spaced further apart and allow for larger movements due to temperature changes.

Dowels: Steel dowels are sometimes placed across joints to transfer load between adjacent slabs and reduce the risk of faulting (vertical displacement).

4. Concrete Placement and Finishing:

Mixing: Concrete is mixed according to the specified design mix, ensuring proper proportions of cement, aggregates, water, and admixtures.

Placement: The concrete is placed on the prepared base course using pavers or other equipment. It's crucial to avoid segregation of ingredients and maintain a consistent thickness.

Consolidation: Vibrating equipment is used to remove air voids and ensure proper compaction of the concrete.

Finishing: The surface is leveled and smoothened using finishing machines or manual tools to achieve the desired profile and texture.

5. Curing:

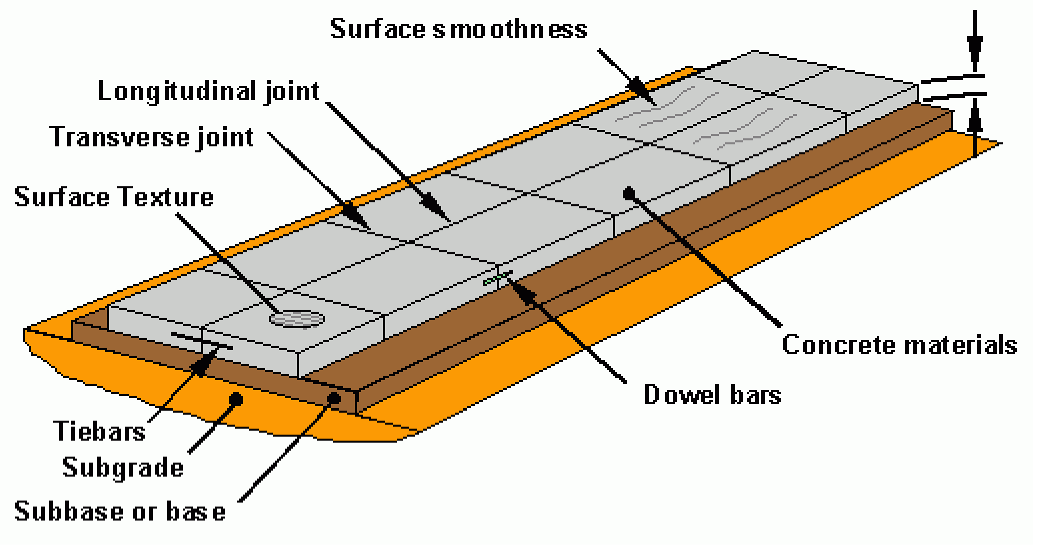
Wet Curing: To prevent premature drying and cracking, the exposed concrete surface is kept moist for several days, typically by covering it with water, burlap, or curing blankets.

Membrane Curing: Alternatively, a curing membrane can be sprayed on the surface to retain moisture and promote proper hydration.

6. Joint Sealing and Texturing:

Joint Sealing: Sealants are applied to joints to prevent water infiltration and joint spalling.

Texturing: The surface can be textured using various methods (e.g., grooving, tining) to improve skid resistance and drainage.



Chapter 8

Low cost roads and General introduction to bridges

8.1 Introduce low cost road.

Low-cost roads are exactly what they sound like - affordable alternatives to standard, high-cost pavement methods. They play a crucial role in developing regions and areas with limited budgets, providing basic access and transportation infrastructure. Here's a breakdown of the concept:

Key Characteristics:

Use readily available materials: Locally sourced aggregates, recycled materials, and stabilized soils are often employed, reducing transportation costs and reliance on expensive resources.

Simpler construction techniques: Labor-intensive methods that require less specialized equipment are favored, making them easier to implement with local knowledge and skills.

Modular and adaptable: Designs can be adjusted to different traffic volumes, soil conditions, and budgets, providing flexibility for diverse needs.

Benefits:

Improved accessibility: Opens up isolated communities, facilitates trade and economic development, and connects people to essential services.

Lower initial investment: Significantly cheaper than conventional roads, making them viable even with limited resources.

Sustainability: Can utilize recycled materials and minimize environmental impact through careful planning and construction methods.

Local job creation: Often rely on local workforce and skills, boosting the local economy and promoting self-reliance.

Examples of Low-cost Roads:

Gravel roads, earthen roads, Surface dressing, Otta seal, and Stabilized soil

Challenges and Considerations:

Durability: Some methods may require more frequent maintenance compared to conventional roads.

Load capacity: Not suited for heavy traffic volumes or large vehicles.

Sustainability: Careful planning and construction techniques are crucial to minimize environmental impact.

Overall, low-cost roads offer a practical and affordable solution for basic transportation needs in regions with limited resources. They can significantly improve accessibility, economic development, and local livelihoods, playing a vital role in building a more connected and equitable world.

8.2 Explain Types and field construction technology.

When it comes to low-cost roads, several types exist, each with its own advantages and limitations. The choice of type depends on factors like local resources, budget, traffic volume, and soil conditions. Here's an overview of common types:

1. Gravel Roads:

Construction: Crushed aggregate spread and compacted over prepared subgrade.

Technology: Basic equipment like graders and compactors.

Advantages: Simple, readily available materials, low initial cost.

Disadvantages: Lower durability, dust issues, requires frequent maintenance.

2. Earthen Roads:

Construction: Simply shaped and compacted native soil.

Technology: Minimal equipment like graders and rollers.

Advantages: Very low cost, locally available materials.

Disadvantages: Poor durability, susceptible to erosion, weather damage.

3. Surface Dressing:

Construction: Thin bituminous layer sprayed on existing road and covered with aggregate chips.

Technology: Sprayers, distributors, and rollers.

Advantages: Improves durability and dust control, relatively low cost.

Disadvantages: Not ideal for heavy traffic, requires good base and maintenance.

4. Otta Seal:

Construction: Similar to surface dressing, but uses graded aggregate for a smoother surface.

Technology: Similar to surface dressing, with emphasis on precise binder application and rolling.

Advantages: More durable than chip seal, smoother ride, good dust control.

Disadvantages: Higher cost than chip seal, requires skilled labor and quality control.

5. Stabilized Soil:

Construction: Soil mixed with binders like cement or lime and compacted.

Technology: Mixing equipment (e.g., pug mills), specialized compactors.

Advantages: Stronger than unstabilized soil, reduces dust, locally sourced materials.

Disadvantages: Requires binder materials, may need specialized equipment.

8.3 Describe Advantages of stage construction of roads.

Stage construction, also known as incremental construction, involves building a road in multiple phases rather than completing it all at once. This approach offers several advantages, especially for projects with budget constraints, uncertain future traffic demands, or challenging environmental conditions. Here are some key benefits:

Financial Advantages:

Lower upfront costs: Requires less initial investment as construction is spread out over time.

Improved cash flow: Allows funding to be secured in stages, easing financial burden.

Phased funding opportunities: May facilitate funding from different sources for each stage.

Traffic and Planning Advantages:

Flexibility for future needs: Initial stages can be built to accommodate lower traffic volumes, with later stages expanded as needed.

Minimized disruption: Reduces overall construction time and disruption to existing traffic and surrounding communities.

Phased testing and monitoring: Early stages provide information on user needs and soil behavior, informing future construction phases.

Technical Advantages:

Adaptability to changing conditions: Allows adjustments to design or materials based on observations made during earlier stages.

Improved subgrade performance: Allows time for subgrade to settle and stabilize before applying heavier loads, potentially reducing long-term maintenance needs.

Reduced environmental impact: Lessens overall disturbance of land and resources than building the entire road at once.

8.4 Definition on Bridge and its types (suspended and Suspension).

A bridge is a structure built to span a physical obstacle such as a water body, valley, or road. It allows for the passage of people, vehicles, or goods from one side to the other.

There are numerous types of bridges, each with its own advantages and disadvantages depending on the specific needs and constraints of the project. Here's a closer look at the terms you mentioned:

I. Bridge Definition:

A bridge is a structure designed to provide passage over an obstacle without interrupting the flow beneath.

It involves supporting a deck or roadway to allow safe and convenient crossing.

Bridges can be built using various materials like concrete, steel, wood, or stone.

II. Bridge Types:

There are many types of bridges, classified based on various criteria like structural form, material, and function. Here are two common classifications:

A. By Structural Form:

Beam bridges: Simple beams supported at both ends, suitable for short spans and light loads.

Truss bridges: Network of interconnected beams forming triangles, offering strength and efficiency for longer spans.

Arch bridges: Curved structure transferring weight downwards to abutments, ideal for long spans and heavy loads.

Cantilever bridges: Beams extending horizontally outwards from supports, often used in conjunction with other bridge types.

Suspension bridges: Suspended deck supported by cables anchored at towers, suitable for very long spans.

B. By Material:

Concrete bridges: Durable and versatile, widely used for various bridge types.

Steel bridges: Strong and lightweight, popular for long-span bridges.

Timber bridges: Traditional and aesthetically pleasing, often seen in shorter spans.

Composite bridges: Utilize combinations of materials like steel and concrete.

III. Suspended vs. Suspension Bridges:

While both use cables to support the deck, there's a subtle difference:

Suspended bridge: Deck directly hangs from cables supported at multiple points along the span (e.g., pedestrian bridges).

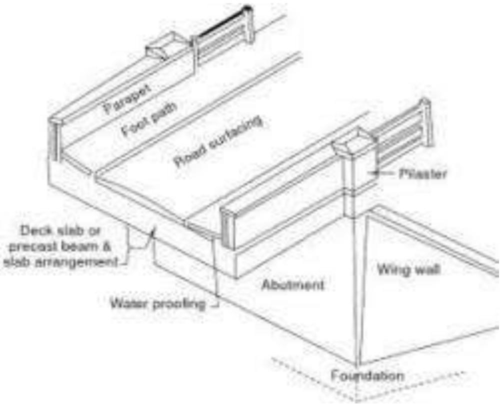
Suspension bridge: Deck hangs from towers connected by main cables anchored at both ends of the bridge (e.g., Golden Gate Bridge).

8.5 Illustrate the components of bridge.

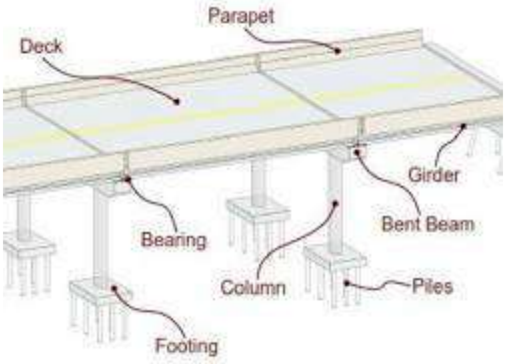
The main components of a bridge can be broadly categorized into three groups:

1. Superstructure: This is the visible part of the bridge that carries the traffic load. It consists of:

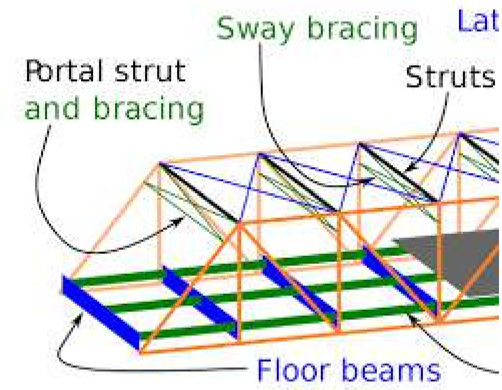
Deck: The flat surface on which traffic travels, made of concrete, steel, or timber.



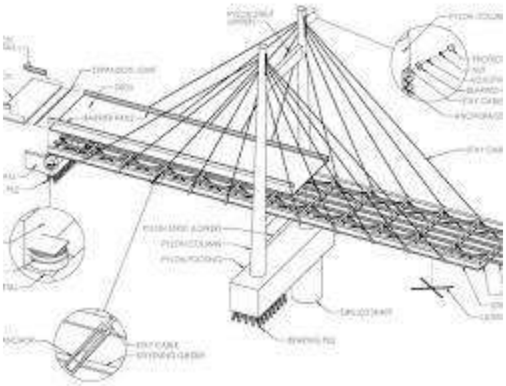
Girders: The main beams that support the deck, typically made of steel or concrete.



Trusses (optional): A network of interconnected beams forming triangles, used in truss bridges to provide additional strength and rigidity.

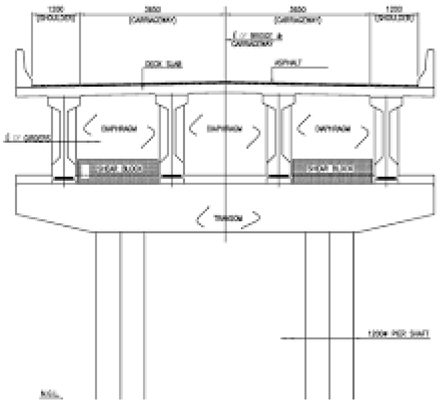


Cables (optional): In suspension bridges, the cables are the primary load-carrying members, suspending the deck from towers.

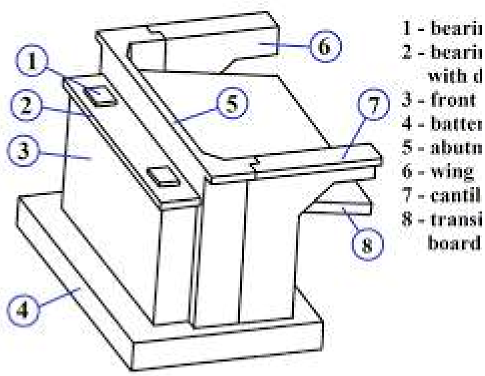


2. Substructure: This is the part of the bridge that supports the superstructure and transfers the load to the ground. It consists of:

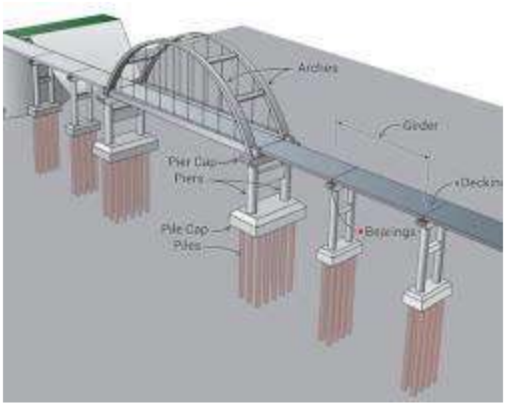
Piers: Vertical supports that rest on foundations and hold up the superstructure. They can be made of concrete, steel, or masonry.



Abutments: Structures at the ends of the bridge that support the ends of the girders and transfer the load to the ground. They are usually made of concrete or masonry.

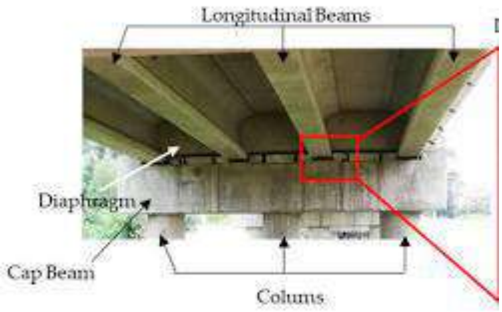


Foundations: These are buried underground and transfer the load from the piers and abutments to the soil or rock below. They can be spread footings, pile foundations, or caissons.



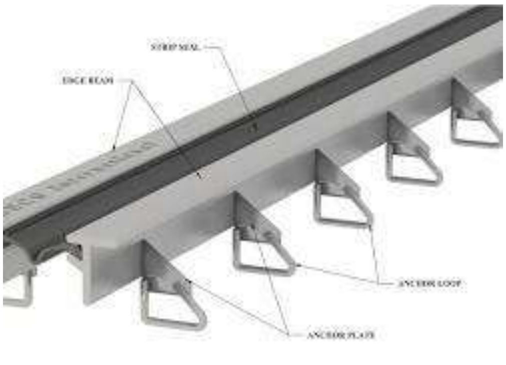
3. Other components:

Bearings: These are located between the superstructure and substructure, allowing for movement and distributing the load evenly.



(a) Bridge bent

Expansion joints: These allow for movement of the bridge deck due to thermal expansion and contraction.



STRIP SEAL EXPANSION JOINT

Safety features: Railings, barriers, and lighting are essential for the safety of pedestrians and vehicles.

Chapter 9

Hill Road

9.1 Write Importance of hill roads and special considerations.

Importance of Hill Roads:

Hill roads play a crucial role in mountainous regions, serving as lifelines for communities and contributing to various aspects of life:

Economic Development:

Improved connectivity: Facilitates transportation of goods and services, enabling trade and market access for remote communities.

Resource access: Enables extraction and transportation of natural resources like timber, minerals, and hydropower, boosting local economies.

Tourism development: Opens up scenic areas, attracting tourists and generating revenue for local businesses.

Social Development:

Healthcare and education: Allows access to medical facilities and educational institutions, improving overall well-being.

Emergency services: Enables rapid response to emergencies and disasters in remote areas.

Community cohesion: Connects isolated communities, fostering communication and cultural exchange.

Strategic Significance:

Military movement: Provides vital infrastructure for military operations and border security.

Disaster relief: Enables access for relief workers and supplies during natural disasters.

National integration: Connects remote regions to the national infrastructure, promoting unity and development.

Special Considerations for Hill Roads:

Due to the challenging terrain, designing and constructing hill roads requires careful consideration of several factors:

Geometric Design:

Steep gradients: Employing techniques like switchbacks and minimizing gradients to ensure safe travel and fuel efficiency.

Hairpin bends: Designing wider curves with proper sight distances for safe maneuvering of vehicles.

Road width: Considering traffic volume and vehicle types to ensure adequate space for passing and maneuvering.

Safety and Stability:

Landslides: Implementing mitigation measures like retaining walls, drainage systems, and geotechnical investigations.

Rockfalls and avalanches: Employing protective structures like rockfall barriers and avalanche sheds.

Erosion control: Using vegetation, gabions, and other measures to prevent erosion and maintain slope stability.

Environmental Impact:

Minimizing deforestation: Choosing alignments that avoid sensitive ecological areas and minimizing tree removal.

Wildlife corridors: Incorporating wildlife crossings and underpasses to maintain animal migration routes.

Sustainable construction: Using local materials, minimizing waste, and implementing proper pollution control measures.

9.2 Define drainage, cross-slope, grade in hill road, hair-pin-bend etc.

Drainage:

Drainage in hill roads refers to the system designed to collect and channel surface water and groundwater away from the road structure. This is crucial to prevent road damage due to erosion, flooding, and instability. Drainage systems in hill roads typically include:

Ditches: Channels along the sides of the road to collect surface water.

Cross-drains: Culverts or pipes that allow water to pass under the road.

Subsurface drains: Pipes or trenches installed below the road surface to collect groundwater.

Cross-slope:

The cross-slope is the tilt of the road surface from the centerline towards the sides. It is also sometimes called the super elevation or camber.

In hill roads, cross-slope plays a crucial role in directing water runoff towards the ditches and preventing water from pooling on the road surface.

The optimal cross-slope depends on factors like road gradient, traffic volume, and rainfall intensity.

Grade:

Grade refers to the longitudinal slope of the road, expressed as a percentage. In hill roads, grade determines the steepness of the incline or decline.

Steeper grades can be dangerous for vehicles, requiring lower speed limits and potentially leading to accidents.

Engineers strive to balance the need for efficient travel with safety considerations when determining the grade of a hill road.

Hairpin Bend:

A hairpin bend is a sharp turn on a hill road, typically 180 degrees or close to it.

They are used to navigate steep inclines while minimizing the overall length of the road.

Hairpin bends require careful design and construction to ensure safe passage for vehicles. This includes wider curves, proper sight distances, and appropriate speed limits.

9.3 Explain retaining walls, breast walls, revetment walls, toe walls and slope protection works.

Slope Stabilization Tools:

When dealing with slopes in construction projects, especially in challenging terrains like hillsides, various techniques are employed to ensure stability and prevent erosion. Here's a breakdown of some key terms:

Retaining Walls:

Retaining walls are robust structures designed to hold back soil and support earth pressure. They are commonly used in situations where a change in elevation needs to be accommodated, such as creating level platforms or preventing soil from collapsing onto lower areas.

Materials for retaining walls vary widely, including concrete, masonry, wood, steel, and gabions (wire baskets filled with stones).

Breast Walls:

Breast walls are smaller versions of retaining walls, typically constructed at the foot of a slope to prevent erosion and provide some lateral support. They are often used along roadways or embankments to retain the soil at the edge and offer aesthetic finishing.

Breast walls usually experience less pressure than retaining walls and utilize similar materials like concrete, stone, or brick.

Revetment Walls:

Revetment walls are structures placed on the face of a slope to protect it from erosion caused by water, wind, or other forces. They are often used along shorelines, riverbanks, and canals to protect against water damage.

Materials for revetment walls can include riprap (large stones), concrete blocks, gabions, or geotextiles (fabric membranes).

Toe Walls:

Toe walls are small walls built at the base of a slope, primarily to improve stability by preventing the toe (bottom) of the slope from eroding or spreading outwards. They are often used in conjunction with other slope protection measures like retaining walls or revetment walls.

Toe walls are typically constructed with concrete, stone, or timber and require careful design to withstand the forces acting on the slope's toe.

Slope Protection Works:

Slope protection works encompass a broader range of techniques used to stabilize slopes and prevent erosion. This can include:

Vegetation: Planting grass, shrubs, or trees with deep root systems to hold soil in place.

Geotextiles: Fabric membranes placed on the slope surface to reinforce the soil and prevent erosion.

Terraces: Creating stepped levels on the slope to break up the angle and reduce erosion.

Anchors: Installing soil anchors like nails or meshes to reinforce the soil mass.

Chapter 10

NRS and Feeder road guidelines

10.1 Practice NRS and Feeder road guidelines.

10.1.1 Width of carriage ways.

Carriageway: The carriageway is the main driving surface of the road. It is typically made of bituminous or asphalt or concrete.

As per NRS 2070 width of carriage way

For single lane highway: 3.75 m

For multilane highway: 3.5 m

For intermediate lane: 5.5 m

10.1.2 Shoulders

As per NRS 2070 the minimum shoulder width for road class I, II, III & class IV should be 3.75 m, 2.5 m, 2.0 m & 1.5 m respectively.

10.1.3 Medians, Camber, Super elevation.

As per NRS 2070 the medians:

a. For roads with 4 or more lanes, it is recommended to provide medians or traffic separators. Medians should be as wide as possible.

b. A minimum median width of 5m is recommended. But a width of 3m can be adopted in areas where land is restricted.

c. In mountainous and steep terrains maximum possible width of median dictated by the topography should be provided. In such situations simple barriers may be provided to function as a median or individual carriageways could be designed at different levels.

d. On long bridges and viaducts the width of the median may be reduced to 1.5m, but in no case this should be less than 1.2m.

e. The median should be of uniform width in a particular section of the highway. However, where changes are unavoidable, a transition of 1 in 20 must be provided.

As per NRS 2070 the camber for different types of pavement shown in table 3.1

Pavement Type	Cement Concrete	Bituminous	Gravel	Earthen
Camber %	1.5 to 2.0	2.5	4	5

As per NRS 2070 the maximum super elevation for different terrain shown in table 3.3

Terrain	In Plain and Rolling Terrain	In snow bound area	In hilly area not bounded by snows
Superelevation, %	7	7	10

10.1.4 Surface Drainage, Embankments, and Side slopes.

a. Side slopes of embankment and cuttings depend on the type of fill/cut materials and height/depth of filling/cutting.

b. Recommended side slopes for embankments are given below. But wherever possible flatter slopes are recommended for aesthetic reason and traffic safety.

Height, m	Side Slope (Vertical: Horizontal)
<1.5	1:4
1.5 – 3.0	1:3
3.0 – 4.5	1:2.5
4.5 – 12.0	1 :2
>12.0	Design Specially

c. If natural cross slope of the ground is more than 1:5 then the ground should be cut with more than 2m wide horizontal steps.

d. Recommended values of side slopes in cutting are given in Table 11-5

Soil type	Side Slope (Vertical: Horizontal)
Ordinary Soil	1:2 to 1:1
Disintegrated rock or conglomerate	1:1/2 to 1:1/4
Soft rock, shale	1:1/4 to 1:1/8
Medium Rock	1:1/12 to 1:1/16
Hard Rock	Almost Vertical

10.1.5 Right of Way, Lateral and vertical clearances.

As per NRS 2070 the right of way for Highways, Feeder Roads and District Roads should be 50 m, 30 m & 20 m respectively.

Lateral clearances

a. For a single carriageway road that goes through an underpass, whole width of the roadway (carriageway plus shoulder widths) should be cleared in lateral direction.

b. If footpaths are provided minimum lateral clearance should be width of footpath plus 1.0m.

c. On roads with divided carriageway, left hand side lateral clearance should be as given on (a.) and (b.) above.

d. Right hand side clearance should be 2.0 m (desirable) with 1.5m minimum.

Vertical clearances

e. A vertical clearance of 5.0m measured from the crown of the road surface shall be provided for whole roadway width on all roads. No obstructions shall be made on this space.

f. Vertical clearance for high voltage electric cables from the road surface shall be as shown in Table 11-7

Voltage, kV	Minimum vertical clearance, m
1	6
110	7
132	7.5
220	8
330	8.5
550	9
720	16

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