- **Class – VII Semester / IV Year**
- **Subject –Transportation Engineering**
- **Unit –1 (Highway Planning and Alignment)**
- **Presented by – Jitesh Kumar Jain (Assistant Professor)**

Department of Civil Engineering,

Jaipur Engineering College and Research Centre Jaipur

VISION

- To become a role model in the field of Civil Engineering for the sustainable development of the society

MISSION

1) To provide outcome base education.
2) To create a learning environment conducive for achieving academic excellence.
3) To prepare civil engineers for the society with high ethical values.

PROGRAMME OUTCOMES (PO)

1. **Engineering knowledge**: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.

2. **Problem analysis**: Identify, formulate, research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.

3. **Design/development of solutions**: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations

4. **Conduct investigations of complex problems**: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.

5. **Modern tool usage**: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.

6. **The engineer and society**: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.

7. **Environment and sustainability**: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.

8. **Ethics**: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.

9. **Individual and team work**: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.

10. **Communication**: Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.

11. **Project management and finance**: Demonstrate knowledge and understanding of the engineering and management principles and apply these to one’s own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.

12. **Life-long learning**: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

COURSE OUTCOMES

Name of Subject – TRANSPORTATION ENGINEERING

Semester- VII **Code – 7CE4-01**

CO1:-Introduction,modes,development,classification,planning & alignment of highway in India.

CO2:-Design of highway & desirable properties, testing of material as per IRC code.

CO 3:-Method of highway construction, Equipment & design of flexible & rigid pavements as per IRC.

CO4:-Introduction of Railway,Waterways,Airways,Engineering

TRANSPORTATION ENGINEERING

- **Transportation engineering** is the application of technology and scientific principles to the planning, functional design, operation and management of facilities for any mode of transportation in order to provide for the safe, efficient, rapid, comfortable, convenient, economical, and environmentally compatible movement of people and goods from one place to other.

MODES OF TRANSPORTATION

- Basic mode of transportation are
  - Land
    - Roadway
    - railway
  - Water
  - Air

MODES OF TRANSPORTATION

- **Highways**
  Car, Bus, Truck, non- motorized ..etc
- **Railways**
  Passenger and Goods
- **Airways**
  Aircraft and Helicopters
- **Waterways**
  Ships, boats…
- **Continuous Flow systems**
  Pipelines,belts,elevetor,ropeway…etc.
- Merits and Demerits: Based on accessibility, mobility, cost, tonnage..

- **Airways**

- Fastest among all other modes
- More comfortable
- Time saving
- Uneconomical

- **Waterways**

- slowest among all other modes
- It needs minimum energy to haul unit load through unit distance.
- This can be possible between ports on the sea routes or along the river
- economical

Railways

- The transportation along the railways track could be advantageous by railways between the stations both for the passengers and goods, particularly for long distance.
- It depends upon the road transport i.e. road could serve as a feeder system.
- Energy require to haul a unit load through unit distance by the railway is only ¼ to 1/5 of that required by road.
- Safety

Highways

- It gives the maximum service to one and all
- It gives maximum flexibility for travel with reference to route, direction, time and speed of travel
- It provide door to door service
- Other modes are depend on it
- It requires small investment for the government
- Motor vehicles are cheaper than other carriers like rail locomotive and wagons
- It saves the time for short distance
- High degree of accident due to flexibility of movement

Scope of Highway Engineering

- Development, planning and location
- Highway design, geometric and structure
- Traffic performance and its control
- Materials, construction and maintenance
- Economic, finance and administration

ROLE /IMPACT OF TRANSPORTATION

- Economic Development
- Social Development
- Spatial Development
- Cultural Development
- Political Development

Characteristics of road transport

- Roads are used by various types of road vehicles, like passenger cars, buses, trucks, pedal cycle and animal drawn vehicle.
- It requires a relatively small investment for the government.
- It offers a complete freedom to road users to transfer the vehicle from one lane to another and from one road to another according to need and convenience.
- Speed and movement is directly related with the severity of accident.
- Road transport is the only means of transport that offers itself to the whole community alike.

HISTORICAL DEVELOPMENT OF ROAD CONSTRUCTION

- Oldest mode

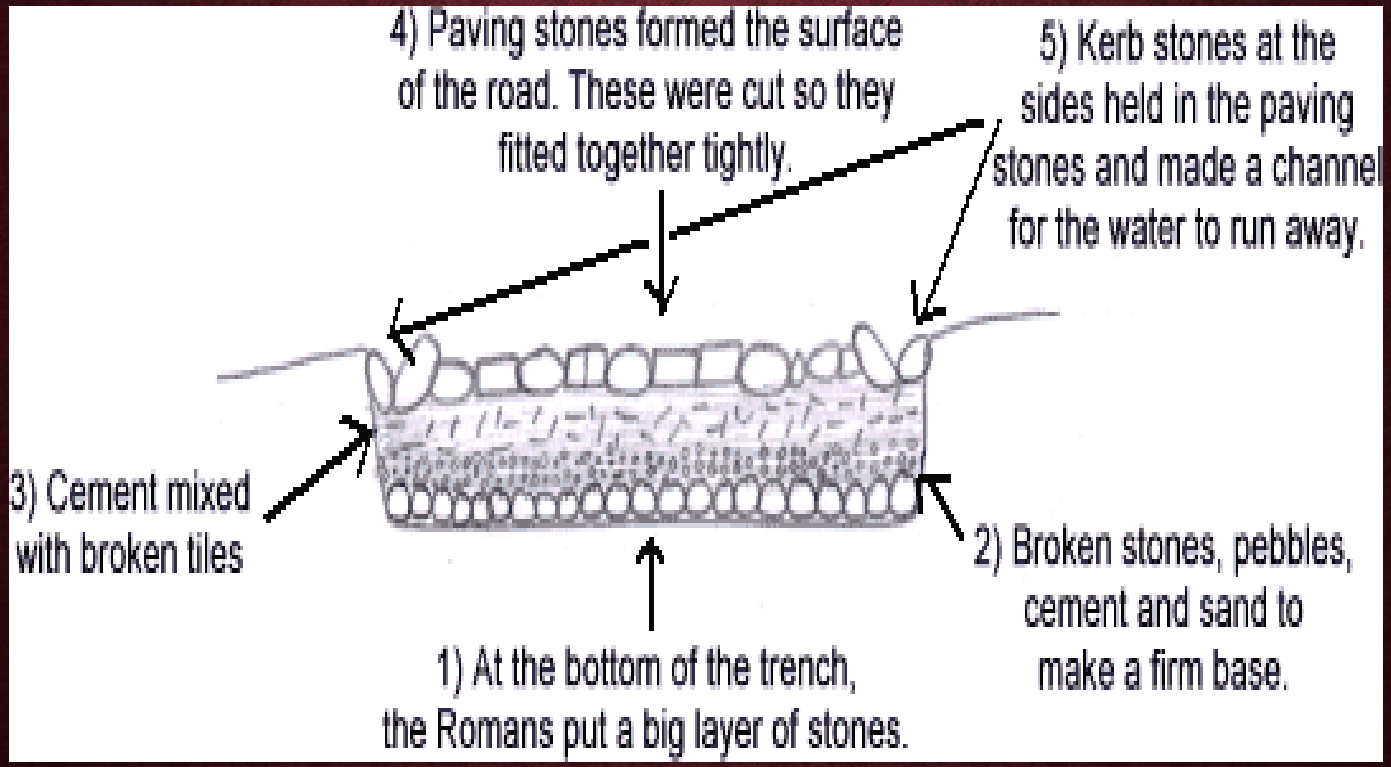
- Foot paths- animal ways, cart path……..

- As civilization evolved the need for transportation increased

ROMAN ROAD-(500 B.C.)

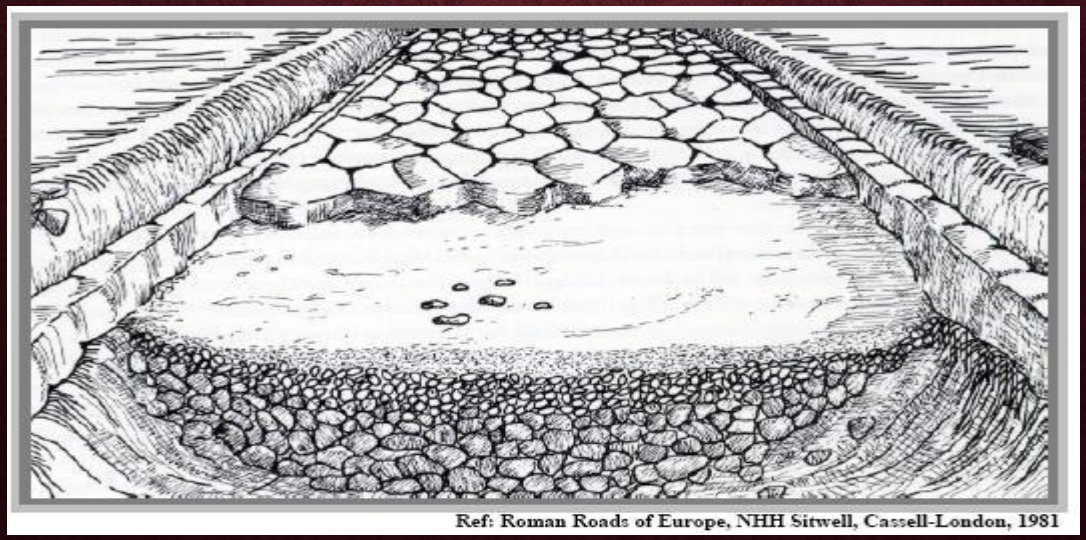
- They were built straight regardless of gradient
- They were built after the soft soil was removed and a hard stratum was reached.
- Thickness varies from 0.75 m to 1.2m

Roman Road Construction
Basic Cross Section



Roman Road

Modern Highway



Ref: Roman Roads of Europe, NHH Sitwell, Cassell-London, 1981

Other oldest road transport are

- Tresaguet construction
- Metcalf construction
- Telford construction
- Mecadam construction

Indian Roads

- India has a large road network of over 3.314 million kilometers of roadways (2.1 million miles), making it 3rd largest road network in the world.

- At 0.66 km of highway per square kilometer of land the density of India’s highway network is higher than that of the United States (0.65) and far higher than that of China's (0.16) or Brazil's (0.20).

Highway Development in India

- Jayakar Committee (1927)
- Central Road Fund (1929)
- Indian Roads Congress (IRC), 1934
- Central Road Research Institute (CRRI), 1950
- Motor vehicle act (1936)
- National Highway Authority of India (NHAI),1995
- First twenty year road plan (1943-61)
- Second twenty year road plan (1961-81)
- Highway Research board (1973)
- National Transport Policy committee (1978)
- Third twenty year road plan (1981-2001)

Jayakar Committee,1927

- After the first World War, motor vehicle using the roads increases, this demanded a better road network.
- In 1927,Indian road development committee was appointed by the government with M.R. Jaykar as chairman.
- Road development in the country should be made as a national interest since local govt. do not have financial and technical capacity for road development.
- An extra tax should be levied on petrol from road users to create the road development fund.
- To establish a semi-official ,technical institution to pool technical knowledge, sharing of ideas and to act as an advisory body.
- To create a national level institution to carry research , development works and consultation.

Central road fund

- It was formed on 1st march 1929
- The consumers of petrol were charged an extra leavy of 2.64 paisa per litre of petrol to built up this road development fund.
- From this 20% of annual reveneu is to be retain as a central reveneu for research and experimental work expenses..etc
- Balance 80% is allowed by central govt. to various states based on actual petrol consumption or revenue collected.

Central Road Fund , 1929

CRF Act , 2000

Distribution of 100% cess on petrol as follows:

- 57.5% for NH
- 30% for SH **MORTH**
- 12.5% for safety works on rail-Road crossing.

50% cess on diesel for Rural Road development

Indian Roads Congress, 1934

- Central semi official body known as IRC was formed in 1934.
- To provide national forum for regular pooling of experience and ideas on matters related to construction and maintenance of highways.
- It is a active body controlling the specification, standardization and recommendations on materials, design of roads and bridges.
- It publishes journals, research publications and standard specifications guide lines.
- To provide a platform for expression of professional opinion on matters relating to roads and road transport.

Motor vehicle act

- It was formed in 1939
- To regulate the road traffic in the form of traffic laws, ordinances and regulations.
- Three phases primarily covered are control of driver, vehicle ownership and vehicle operation
- It was revised on 1988

Central road research institute(1950)

- engaged in carrying out research and development projects.
- design, construction and maintenance of roads and runways, traffic and transportation planning of mega and medium cities, management of roads in different terrains,
- Improvement of marginal materials.
- Utilization of industrial waste in road construction.
- Landslide control.
- Ground improvements, environmental pollution.
- Road traffic safety.

Ministry of Road Transport & Highways

- Planning, development and maintenance of National Highways in the country.
- Extends technical and financial support to State Governments for the development of state roads and the roads of inter-state connectivity and economic importance.
- Evolves standard specifications for roads and bridges in the country.
- It stores the data related to technical knowledge on roads and bridges.

Highway Research Board

- To ascertain the nature and extent of research required
- To correlate research information from various organisation in India and abroad.
- To collect and correlation services.
- To collect result on research
- To channelize consultative services

Classifications Of Highways

Depending on weather

- All weather roads
- Fair weather roads

Depending the type of Carriage way

- Paved roads(WBM)
- Unpaved roads(earth road or gravel road)

Depending upon the pavement surface

- Surfaced roads(bituminous or cement concrete road)
- Un surfaced roads

Based on the Traffic Volume

- Heavy
- Medium
- Light

Based on Load or Tonnage

Class 1 or Class 2 etc or Class A , B etc
Tonnes per day

Based on location and function (Nagpur road plan)

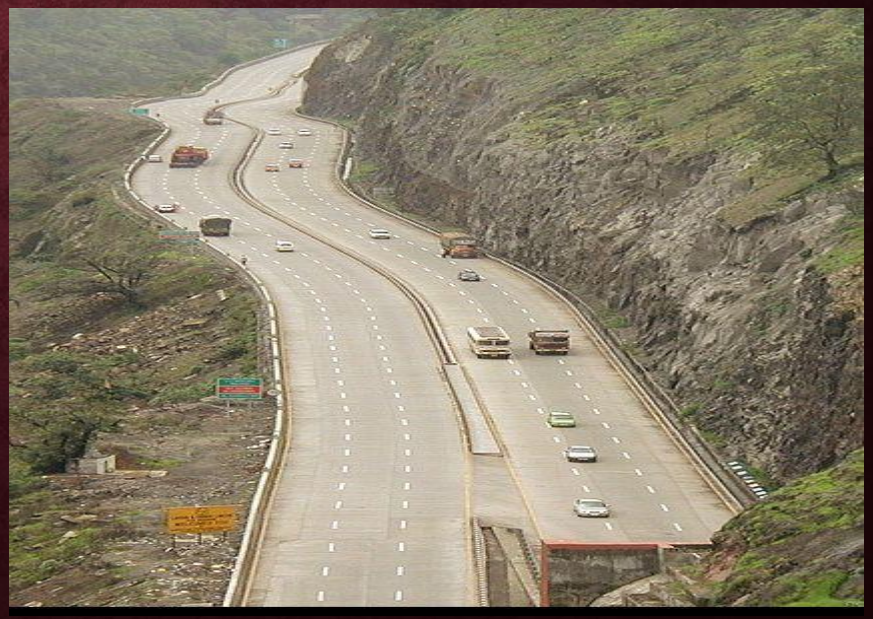
- National highway (NH)
- State highway (SH)
- Major district road (MDR)
- Other district road (ODR)
- Village road (VR)

Based on modified system of Highways classification

- **Primary**
  - Expressways
  - National Highways
- **Secondary**
  - SH
  - MDR
- **Tertiary**
  - ODR
  - VR

Expressways

- Heavy traffic at high speed (120km/hr)
- Land Width (90m)
- Full access control
- Connects major points of traffic generation
- No slow moving traffic allowed
- No loading, unloading, parking.



The Mumbai-Pune Expressway as seen from Khandala

National Highways

- NH are the main highways running through the length and breadth of India, connecting major parts,foreign highways,capital of large states and large industrial and tourist centres including roads required for strategic movements for the defence of India.
- The national highways have a total length of 70,548 kms. Indian highways cover 2% of the total road network of India and carry 40% of the total traffic.
- The highway connecting Delhi-Ambala-Amritsar is denoted as NH-1, whereas a bifurcation of this highway beyond Jalandar to Srinagar and Uri is denoted NH-1-A
- The longest highway in India is NH7 which stretches from Varansi in Uttar Pradesh to Kanyakumari in the southern most point of Indian mainland.

- The shortest highway is NH47A which stretches from Ernakulam to Kochi and covers total length of 4 Kms.
- **<u>Golden Quadrilateral</u> – (5,846 Kms) connecting Delhi- Kolkata-Chennai-Mumbai**

➢ NH-2 Delhi- Kol (1453 km)

➢ NH 4,7&46 Che-Mum (1290km

➢ NH5&6 Kol- Che (1684 m)

➢ NH 8 Del- Mum (1419 km)

State Highways

- They are the arterial roads of a state, connecting up with the national highways of adjacent states, district head quarters and important cities within the state.
- Total length of all SH in the country is 1,37,119 Kms.
- Speed 80 kmph.

Major District Roads

- Important roads with in a district serving areas of production and markets , connecting those with each other or with the major highways.
- India has a total of 4,70,000 kms of MDR.
- Speed 60-80kmph

Other district roads

- serving rural areas of production and providing them with outlet to market centers or other important roads like MDR or SH.
- Speed 50-60kmph

Village roads

- They are roads connecting villages or group of villages with each other or to the nearest road of a higher category like ODR or MDR.
- India has 26,50,000 kms of ODR+VR out of the total 33,15,231 kms of all type of roads.
- Speed-40-50kmph

Road Patterns

- Rectangular or Block patterns
- Radial or Star block pattern
- Radial or Star Circular pattern
- Radial or Star grid pattern
- Hexagonal Pattern
- Minimum travel Pattern

FIRST 20-YEAR ROAD PLAN

- The conference of chief engineer held at Nagpur in 1943 finalized the first 20-years road development plan for India called Nagpur road plan
- Road network was classified into five categories.
- The responsibility of construction maintenance of NH was assign to central govt.
- The target road length was 5,32,700 km at the end of 1961.
- Density of about 16km of road length per 100 sq. km area would be available in the country by the year 1963.

FIRST 20-YEAR ROAD PLAN-CONT….

- The formulae were based on star and grid pattern of road network.
- An allowance of 15% is provided for agricultural industrial development during the next 20-years
- The length of railway track in the area was also consider in deciding the length of first category road. The length or railway track is directly subtracted from the estimated road length of metalled roads.

SECOND 20-YEARS ROAD PLAN(1961-81)

- It was initiated by the IRC and was finalised in 1959 at the meeting of chief engineers.
- It is known as the Bombay road plan.
- The target road length was almost double that of Nagpur road plan i.e. 10,57,330 km.
- Density about 32 km per 100 sq. km. and an outlay of 5200 crores
- Every town with population above 2000 in plans and above 1000 in semi hill area and above 500 in hilly area should be connected by metalled road

SECOND 20-YEARS ROAD PLAN(1961-81) CONT…

- the maximum distance from any place in a semi develop area would be 12.8 km from metalled road and 4.8 from any road
- Expressways have also been considered in this plan and 1600km of length has been included in the proposed target NH
- Length of railway track is considered independent of road system
- 5% are to be provided for future development and unforeseen factor

THIRD 20-YEARS ROAD PLAN(1981-2001)

- The future road development should be based on the revised classification of roads system i.e. primary, secondary and tertiary
- Develop the rural economy and small towns with all essential features.
- Population over 500 should be connected by all weather roads.
- Density increases to 82 km per 100 sq. km
- The NH network should be expanded to form a square grids of 100 km sides so that no part of the country is more than 50 km away from the NH

THIRD 20-YEARS ROAD PLAN(1981-2001) CONT…

- Expressway should be constructed along major traffic corridors
- All towns and villages with population over 1500 should be connected by MDR and villages with population 1000-1500 by ODR.
- Road should be built in less industrialized areas to attract the growth of industries
- The existing roads should be improved by rectifying the defects in the road geometry, widening, riding quality and strengthening the existing pavement to save vehicle operation cost and thus to conserve energy

HIGHWAY ALIGNMENT AND SURVEYS

Highway alignment

- The position or lay out of centre line of the highway on the ground is called the alignment.
- It includes straight path, horizontal deviation and curves.
- Due to improper alignment , the disadvantages are,
  - Increase in construction
  - Increase in maintenance cost
  - Increase in vehicle operation cost
  - Increase in accident cost
- Once the road is aligned and constructed, it is not easy to change the alignment due to increase in cost of adjoining land and construction of costly structure.

Requirements of highway alignment

- Short
- Easy
- Safe
- Economical

- Short- desirable to have a short alignment between two terminal stations.
- Easy- easy to construct and maintain the road with minimum problem also easy for operation of vehicle.
- Safe- safe enough for construction and maintenance from the view point of stability of natural hill slope, embankment and cut slope also safe for traffic operation.
- Economical- total cost including initial cost, maintenance cost and vehicle operation cost should be minimum.

Factors controlling alignment

- Obligatory points
- Traffic
- Geometric design
- Economics
- Other considerations

  Additional care in hill roads
- Stability
- Drainage
- Geometric standards of hill roads
- Resisting length

Factors controlling alignment cont...

Obligatory points

- Obligatory points through which alignment is to pass

  Examples:-bridge site, intermediate town , Mountain pass etc…

- Obligatory points through which alignment should not pass.

  Examples:-religious places, costly structure, unsuitable land etc…

Traffic

- origin and destination survey should be carried out in the area and the desire lines be drawn showing the trend of traffic flow.
- New road to be aligned should keep in view the desired lines, traffic flow patterns and future trends.

Geometric design

- Design factors such as gradient ,radius of curve and sight distance also govern the final alignment of the highway.
- Gradient should be flat and less than the ruling gradient or design gradient.
- Avoid sudden changes in sight distance, especially near crossings
- Avoid sharp horizontal curves
- Avoid road intersections near bend

Economy

- Alignment finalised based on total cost including initial cost, maintenance cost and vehicle operation cost.

Other consideration

- Drainage consideration, political consideration
- Surface water level, high flood level
- Environmental consideration

Topographical control points

- The alignment, where possible should avoid passing through
  - Marshy and low lying land with poor drainage
  - Flood prone areas
  - Unstable hilly features

Materials and constructional features

- Deep cutting should be avoided
- Earth work is to be balanced; quantities for filling and excavation
- Alignment should preferably be through better soil area to minimize pavement thickness
- Location may be near sources of embankment and pavement materials

Stability

- A common problem in hilly roads is land sliding
- The cutting and filling of the earth to construct the roads on hilly sides causes steepening of existing slope and affect its stability.

Drainage

- Avoid the cross drainage structure
- The number of cross drainage structure should be minimum.

Geometric standard of hilly road

- Gradient, curve and speed
- Sight distance, radius of curve

Resisting length

- The total work to be done to move the loads along the route taking horizontal length, the actual difference in level between two stations and the sum of the ineffective rise and fall in excess of floating gradient. Should kept as low as possible.

Engineering Surveys for Highway locations

Before a highway alignment is finalised in highway project, the engineering survey are to be carried out. The various stages of engineering surveys are

- **Map study (Provisional alignment Identification)**
- **Reconnaissance survey**
- **Preliminary survey**
- **Final location and detailed surveys**

MAP STUDY

- From the map alternative routes can be suggested in the office, if the topographic map of that area is available.
- The probable alignment can be located on the map from the fallowing details available on the map.

➢ Avoiding valleys, ponds or lake

➢ Avoiding bend of river

➢ If road has to cross a row of hills, possibility of crossing through mountain pass.

Map study gives a rough guidance of the routes to be further surveyed in the field

RECONNAISSANCE SURVEY

- To confirm features indicated on map.
- To examine the general character of the area in field for deciding the most feasible routes for detailed studies.
- A survey party may inspect along the proposed alternative routes of the map in the field with very simple instrument like abney level, tangent clinometer, barometer etc…. To collect additional details.
- Details to be collected from alternative routes during this survey are,

➢ Valleys,ponds,lakes,marshy land, hill, permanent structure and other obstruction.

➢ Value of gradient, length of gradient and radius of curve.

- Number and type of cross drainage structures.
  - High Flood Level (HFL)
  - Soil Characteristics.
  - Geological features.
  - source of construction materials- stone quarries, water sources.
- Prepare a report on merits and demerits of different alternative routs.
- As a result a few alternate alignments may be chosen for further study based on practical considerations observed at the site.

Preliminary survey

Objective of preliminary survey are:

- To survey the various alternative alignments proposed after the reconnaissance and to collect all the necessary physical information and detail of topography, drainage and soil.
- To compare the different proposals in view of the requirements of the good alignment.
- To estimate quantity of earthwork materials and other construction aspect and to workout the cost of the alternate proposals.

Methods of preliminary survey:

a) Conventional approach-survey party carries out surveys using the required field equipment, taking measurement, collecting topographical and other data and carrying out soil survey.

- Longitudinal and cross sectional profile.
  - Plain Terrain` : 100 – 200m
  - Rolling Terrain : 50m
  - Hilly Terrain : 30m
- Other studies
  - Drainage, Hydrological survey, soil survey, Traffic and Material survey.

b)Modern rapid approach-

By Aerial survey taking the required aerial photographs for obtaining the necessary topographic and other maps including details of soil and geology.

- Finalisethe best alignment from all considerations by comparative analysis of alternative routes.

Final location and detailed survey

- The alignment finalised at the design office after the preliminary survey is to be first located on the field by establishing the centre line.

Location survey:

- Transferring the alignment on to ground.
- This is done by transit theodolite.
- Major and minor control points are established on the ground and centre pegs are driven, checking the geometric design requirements.
- Centre line stacks are driven at suitable intervals, say 50m interval in plane and rolling terrains and 20m in hilly terrain.

Detailed survey:

- Temporary bench marks are fixed at intervals of about 250m and at all drainage and under pass structure.
- Earthwork calculations and drainage details are to be workout from the level books.
- Cross sectional levels are taken at intervals of 50-100m in Plane terrain, 50-75m in Rolling terrain, 50m in built-up area, 20m in Hill terrain.
- Detail soil survey is to be carried out.
- CBR value of the soils along the alignment may be determined for design of pavement.
- The data during detailed survey should be elaborate and complete for preparing detailed plans, design and estimates of project.

DRAWINGS & REPORTS

- Key map
- Index map
- Preliminary survey plans
- Detailed plan and longitudinal section
- Detailed cross section
- Land acquisition plans
- Drawings of cross drainage and other retaining structures
- Drawings of road intersections
- Land plans showing quarries etc

NEW HIGHWAYS PROJECTS

- Map study
- Reconnaissance survey
- Preliminary survey
- Location of final alignment
- Detailed survey
- Material survey
- Geometric and structural design
- Earth work
- Pavement construction
- Construction controls

BIBLIOGRAPHY

- Khanna, S. K., & Justo, C. E. G. *Highway engineering. Nem Chand & Bros.*
- *IRC Codes.*