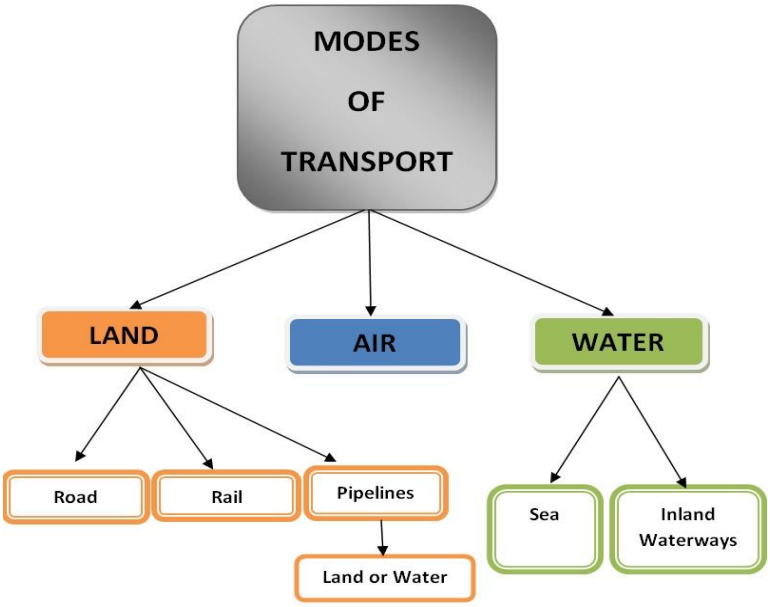
HIGHWAY DEVELOPMENT AND PLANNING

INTRODUCTION:

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.

DIFFERENT MODES OF TRANSPORTATION:



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

Prepared by K. NAGA BHUSHANAM, M. TECH, AMIE

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.

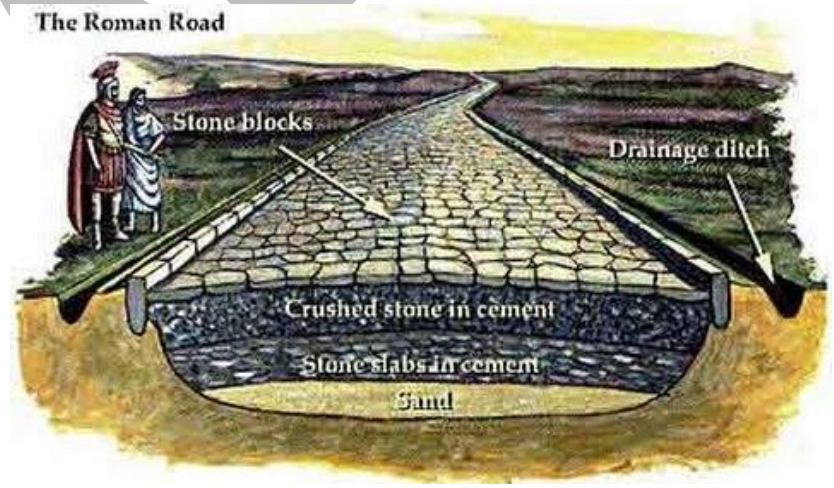
HISTORICAL DEVELOPMENT OF ROAD CONSTRUCTION:

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.



Other oldest road transport:

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

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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. Jaykaras 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 called **"Central Road 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 levy of 2.64 paisa per liter of petrol to build up this road development fund.
- From this 20% of annual revenue is to be retain as a central revenue 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% on petrol as follows:

- 57.5% for NH
- 30% for SH
- 12.5% for safety works on Rail-Road crossing.
- 50% on diesel for Rural Road development

Indian Roads Congress, 1934:

- Central semiofficial 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 an 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 organization in India and abroad.
- To collect and correlation services.
- To collect result on research.
- To channelize consultative services.

First 20-years road plan (1943-63) (Nagpur road congress 1943):

- 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.
- The formulae were based on star and grid pattern of road network.

- The roads were divided into four classes: –
    - **National highways** which would pass through states, and places having national importance for strategic, administrative and other purposes.
    - **State highways** which would be the other main roads of a state.
    - **District roads** which would take traffic from the main roads to the interior of the district. According to the importance, some are considered as **major district roads** and the remaining as **other district roads**.
    - **Village roads** which would link the villages to the road system.
- 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 metaled roads.

Second 20-years road plan (1961-81) (Bombay road congress 1961):

- The length of roads under the Nagpur plan was achieved by the end of it, but the road system was deficient in many respects.
- It was initiated by the IRC and was finalized in 1959 at the meeting of chief engineers.
- 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.
- The maximum distance from any place in a semi develop area would be 12.8 km from metaled 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.
- 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 metaled road.
- The changed economic, industrial and agricultural conditions in the country warranted a review of the Nagpur plan. Accordingly, a 20-year plan was drafted by the Roads wing of Government of India, which is popularly known as the Bombay plan. The highlights of the plan were:

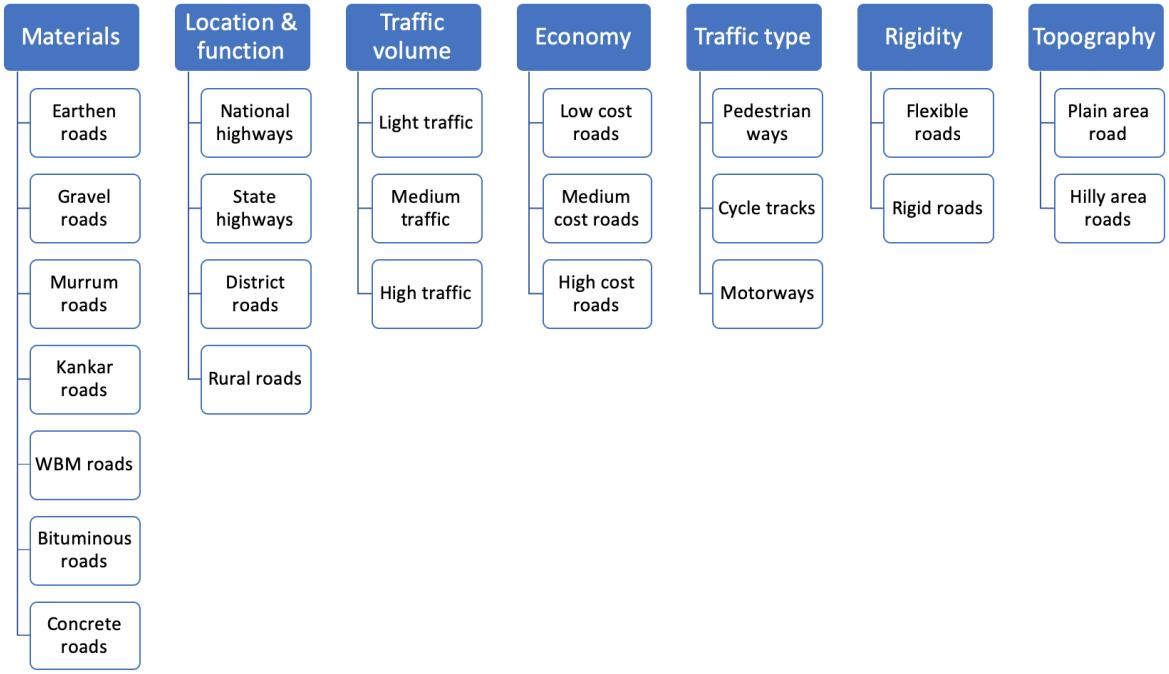
- The total road length targeted to construct was about 10 lakhs.
- Rural roads were given specific attention. Scientific methods of construction were proposed for the rural roads. The necessary technical advice to the Panchayats should be given by State PWD's.
- They suggested that the length of the road should be increased so as to give a road **density of 32kms/100 sq.km**.
- The construction of **1600 km of expressways** was also then included in the plan.

Third twenty years' road plan (1981-2001) (Lucknow road congress 1984):

- This plan has been prepared keeping in view the growth pattern in various fields by the turn of the century. Some of the salient features of this plan are as given below:
- It aimed at constructing a **road length of 12 lakh kilometers** by the year 1981 resulting in **a road density of 82kms/100 sq.km.**
- The plan has set the target length of NH to be completed by the end of seventh, eighth and ninth five-year plan periods.
- It aims at **improving the transportation facilities in villages, towns etc**. such that no part of country is farther than 50 km from NH.
- One of the goals contained in the plan was that expressways should be constructed on major traffic corridors to provide speedy travel.
- Energy conservation, environmental quality of roads and road safety measures were also given due importance in this plan.
- 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.**
- 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.

Classification or Types of Roads

Road Classification based on the following factors



National Highways: National highways are main roads of a particular country. They connect all major cities to the capital of the country. They run throughout the length and breadth of the country. Minimum two lane road is provided for national highways.

State Highways: State highways are second main roads which connect major parts of state with in it. State highway ultimately connects to the national highways.

District Roads: District roads are provided with in the cities and connects markets and production places to state and national highways. Two types of district roads are there namely,

- Major district roads
- Minor district roads

Major district roads connect headquarters of neighbouring district with main parts of district while minor district roads are laid with in the district.

Rural Roads or Village Roads: Village roads connects the nearby villages with each other. They lead to nearby town or district roads. Usually low quality roads are provided as village roads because of low traffic.

ROAD PATTERNS:

Road network can be laid in various patterns. These patterns in which the road network is laid could be

- Rectangular or Block pattern
- Radial or Star and block Pattern
- Radial or Star and Circular Pattern
- Radial or Star and Grid Pattern
- Hexagonal Pattern
- 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. The main road is provided a direct approach to outside the city.

Advantages:

- The rectangular plots may be further divided into small rectangular blocks for construction of buildings placed back to back, having roads on their front.
- In this pattern has been adopted for the city roads.
- The construction and maintenance of roads of this pattern is comparatively easier.

Limitations:

- This pattern is not very much convenient because at the intersections, the vehicles face each other.

Example:

- Chandigarh has rectangular pattern

b) Radial or Star and block Pattern:

In this pattern, the entire area is divided into a network of roads radiating from the business outwardly. In between radiating main roads, the built-up area may be planned with rectangular block.

Advantage:

- Reduces level of congestion at the primary bottleneck location.

- Prevents traffic from accessing local flow routes in the direction of the event venue that operate in favor of egress traffic flow.
- If one is block then other side traffic can move.
- Vehicles face each other less than block pattern.

Limitations:

- Proves particularly effective if two-lane ramp traffic does not have to merge at downstream end of ramp.
- Safety appurtenances such as guide rail transitions, crash attenuators, and post support bases have not been designed to provide adequate protection at hazardous locations from the opposite direction of travel.

Example: Chandigarh has rectangular pattern

c) Radial or Star and Circular Pattern:

In this system, the main radial roads radiating from central business area are connected together with concentric roads. In these areas, boundary by adjacent radial roads and corresponding circular roads, the built-up area is planned with a curved block system.

Advantages:

- At traditional intersections with stop signs or traffic signals, some of the most common types of crashes are right-angle, left-turn, and head-on collisions. These types of collisions can be severe because vehicles may be traveling through the intersection at high speeds. With circular pattern, these types of potentially serious crashes essentially are eliminated because vehicles travel in the same direction.
- Installing circular pattern in place of traffic signals can also reduce the likelihood of rear-end crashes.
- Removing the reason for drivers to speed up as they approach green lights and by reducing abrupt stops at red lights.
- Because roundabouts improve the efficiency of traffic flow, they also reduce vehicle emissions and fuel consumption.

Limitations:

- Centre lines of roads leading to circular pattern should be properly aligned with the central island.
- Approach roads should be sufficiently curved, far enough in advance of circular pattern, to reduce vehicle speeds of entering drivers.

- Islands separating the approach and exit lanes, known as splitter islands, should extend far enough to provide pedestrian refuge and to delineate the roundabout.
- Traffic signs, pavement markings, and lighting should be adequate so that drivers are aware that they are approaching a roundabout and that they should reduce their travel speed.
- For older driver's declines in vision, hearing, and cognitive functions, as well as physical impairments, may affect some older adults' driving ability. Intersections can be especially challenging for older drivers.

Example:

Intersection with traffic signals converted to a circular pattern in Asheville, North Carolina

d)Radial or Star and Grid Pattern:

Change in direction, and because street patterns are the most enduring physical element of any layout, it could potentially contribute to systematic site planning and, consequently, deserves a closer look. Though the network is entirely interconnected, north-south movement becomes circuitous, indirect, and inconvenient, making driving an unlikely choice and vividly illustrating that interconnectedness by itself is insufficient to facilitate movement.

Advantages:

- Keep vehicular traffic safe with a high proportion of 3-way intersections.
- Reduce cut-through traffic by similar or other means.
- Improve traffic flow in both directions using Savannah's cellular structure.
- Improve land use efficiency and unit density.

Limitations:

- Islands separating the approach and exit lanes, known as splitter islands, should extend far enough.
- Traffic signs, pavement markings, and lighting should be adequate so that drivers are aware that they should reduce their travel speed.

Examples:

The Nagpur road plan formulae were prepared on the assumption of Grid pattern.

e) Hexagonal Pattern:

In this pattern, the entire area is provided with a network of roads formatting hexagonal figures. At each corner of the hexagon, three roads meet the built-up area boundary by the sides of the hexagons is further divided in suitable sizes.

Advantages:

Three roads meet the built-up area boundary by the sides of the hexagons.

Limitations:

Traffic signs, pavement markings, and lighting should be adequate so that drivers are aware that they should reduce their travel speed.

f) Minimum Travel Pattern:

In this road pattern, city is contented by sector center, suburban center and neighbourhood center by the road which required minimum to connect the city center.

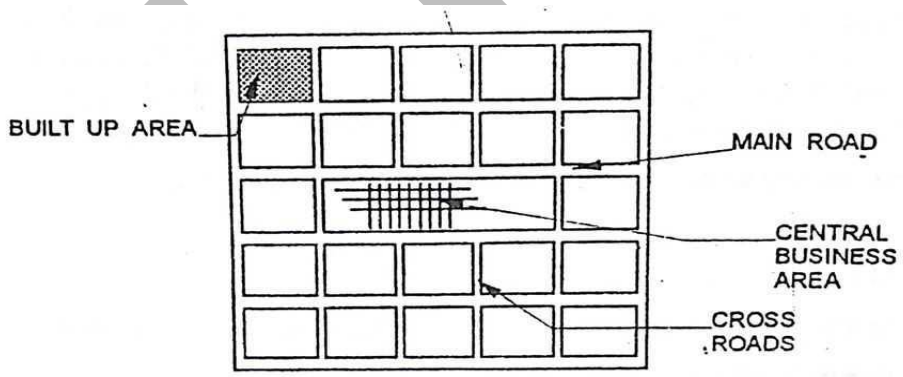
Legend: City center – encircled dot- sector center - * suburban center - * neighbourhood center - *representation of a Minimum Travel city

Advantages:

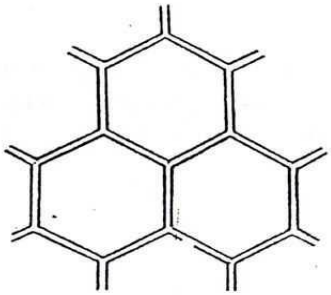
These types of potentially serious crashes essentially are eliminated.

Limitations:

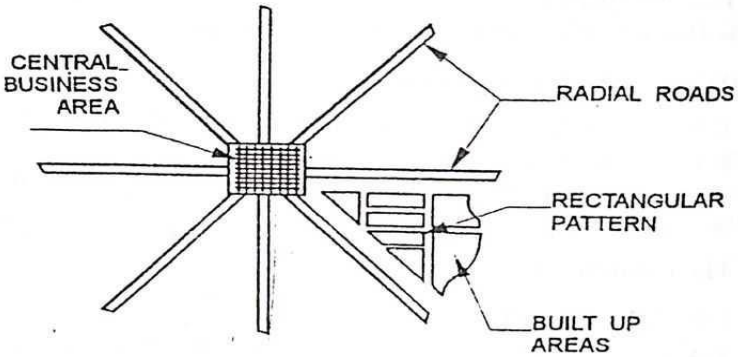
- Traffic signs, pavement markings, and lighting should be adequate so that drivers are aware that they should reduce their travel speed.
- Intersections can be especially challenging for older drivers.



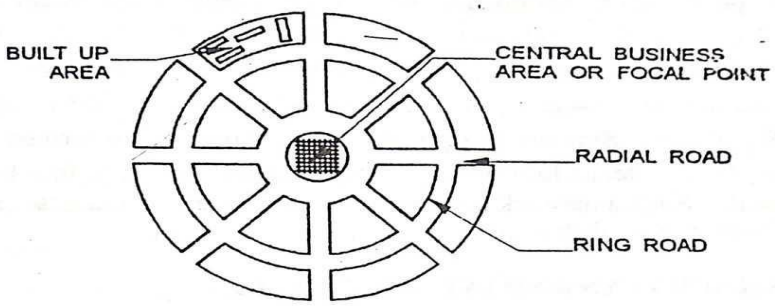
(a) Rectangular or block pattern



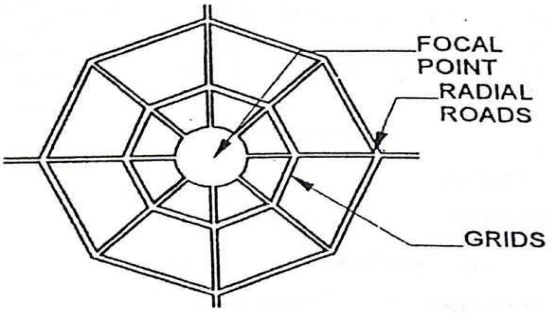
(b) Hexagonal pattern



(c) Radial or star and block pattern



(d) Radial or star and circular pattern



(e) Radial or star and grid pattern

Highway Alignment:

The center line layout or position on the ground surface is called Alignment. There are two types of Alignments (Horizontal Alignment and Vertical Alignment).

- **Horizontal Alignment** includes the straight path, curves or deviation in horizontal direction.
- **Vertical Alignment** includes vertical curves and gradient on the ground.

But it is difficult to change the alignment once the road is construction, so care has to be taken in finalizing the alignment.

Basic Requirement of an Ideal Alignment

- It should have a shortest path.
- The alignment must be easy to construct and maintain and also it should be easy for vehicle operation.
- It should be safe in case of designing the horizontal and vertical curves.
- The alignment should be selected in such a way that it is economical during construction.

Factors Controlling Alignment

1.Obligatory Points

- These are control points governing the alignment of Highways.
- Points through which the Alignment has to pass.
- Hill Pass
- Location of Bridge
- Connecting Intermediate Town
- Avoiding an Intermediate Area
- Points through which the Alignment should not pass
- If it is a case of religious place like temple, mosque, church, grave etc. The Alignment should not pass as per law.

2.Traffic

- Alignment should be selected based on traffic surveys. Origin and Destination study should be carried out in that area and also we have to consider the future development in that road network.

3.Geometric Design

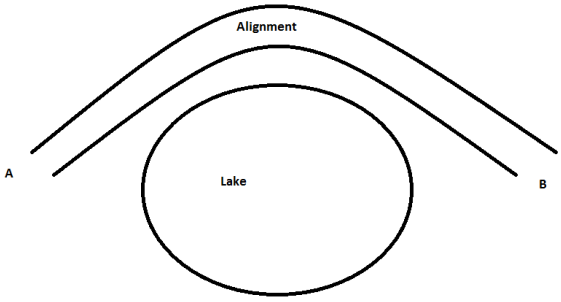
- Alignment is decided based on the design of horizontal and vertical curves, sight distance and gradient of that section. It is also decided based on the Design Speed of that Highway.

4.Economy

- It is based on the initial cost of construction and maintenance cost of the road, if it a shortest path the cost of construction will be reduced. (Decision is based on Quantity of Cutting and Filling of Earth.)

5. Special considerations or care for Hill Roads

- Common problems in hill roads are land sliding, stability of road, providing adequate drainage facility, reducing hairpin bends, needless raise and fall.



Highway Route Surveys and Location:

To determine the geometric features of road design, the following surveys must be conducted after the necessity of the road is decided.

A variety of survey and investigations have to be carried out by Road engineers and multidiscipline persons.

a) Transport Planning Surveys
   - ✓ Traffic Surveys
   - ✓ Highway inventories
   - ✓ Pavement Deterioration Study
   - ✓ Accident study

b) Alignment and Route location surveys
   - ✓ Desk study
   - ✓ Reconnaissance
   - ✓ Preliminary Survey
   - ✓ Final location survey

c) Drainage Studies
   - ✓ Surface run- off: Hydrologic and hydraulic
   - ✓ Subsurface drainage: Ground water & Seepage
   - ✓ Cross–drainage: Location and waterway area required for the cross-drainage structures.

d) Soil Survey
   - ✓ Desk study
   - ✓ Site Reconnaissance

e) E. Pavement Design Investigation Soil property and strength, Material Survey

Drawings and Reports in a Highway Project:

Drawings:

Following drawings are usually prepared in a highway project report:

- KEY MAP
- INDEX MAP
- PRELIMINARY SURVEY PLANS
- DETAILED PLAN & LONGITUDINAL SECTIONS

- DETAILED CROSS-SECTION
- LAND ACQUISITION PLANS
- DRAWING OF CROSS DRAINAGE AND OTHER RETAINING STRUCTURES
- DRAWING OF ROAD INTERSECTIONS
- LAND PLANS SHOWING QUARRIES

KEY MAP should show the proposed & existing roads, & important places to be connected. The size of the plan in general should not exceed 22x20cm. Scale of the map is chosen suitably according to the length of road/highway.

INDEX MAP should show the general topography of the area/site. Details are represented using symbols. Index map should also be of suitable scale, size being 32x20cm.

PRELIMINARY SURVEY PLANS are plans showing details of various alternate alignments & all information collected should be drawn to a suitable scale of 10cm=1Km to 25cm=1Km.

DETAILED PLAN shows the ground plan with alignment & the boundaries, contours at intervals of 1 to 2 metre in plain terrain and 3 to 6 metre in hilly terrain, showing all details including existing structures. Scale of 1/2400 or 1/1200 is suitable for detailed plans. Size of drawing may be A-2 or 60x42 cm approximately.

LONGITUDINAL SECTIONS should be drawn to the same horizontal scale of the ground as in detailed plan. Vertical scale may be enlarged 10 times of the longitudinal scale. The longitudinal section should show details such as datum line, existing ground surface, and vertical profile of the proposed road and position of drainage crossings.

DETAILED CROSS-SECTION are generally drawn to natural scale of 1cm=2.0 to 2.5 metre. Cross section should be drawn every 100 metre or where there are abrupt changes in level. In hill roads the cross section should be drawn at closer intervals. The cross section drawing should extend at least up to the proposed right of way. The cross section number, the reduced distances and the area of filling or cutting (or both) should be shown on cross section drawing.

LAND ACQUISITION PLANS & SCHEDULES are usually prepared from the survey drawings for land acquisition details. These plans show all general details such as building, wells, nature of gradients and other details required for assessing the values. The scale may be 1cm=40 metre or less.

DETAILED DESIGN FOR CROSS DRAINAGE AND MASONRY STRUCTURES are usually drawn to scale of 1cm=1 metre. For details of any complicated portion of the structure enlarged scales up to 8cm=1metre or up to half full size may be employed. However, the size

of drawing should not exceed the standard size. Cross sections of streams should be to a scale of not less than 1cm=10 metre.

Drawing of road intersections should be prepared showing all details of pavement, shoulders, islands etc. to proper scale.

LAND PLANS FOR QUARRIES where quarries for construction materials are to be acquired for new projects, separate land plans should be prepared. The size of these maps and scales may be similar to those proposed under land acquisition.

ESTIMATES:

The project estimates should consist of general abstract of cost and detailed estimates for each major head. If the project work is proposed to be executed in stages the estimate should be prepared for each stage separately.

PROJECT REPORT:

The first phase of project report soon after completing the preliminary surveys, feasibility and ENVIRONMENTAL IMPACT ASSESSMENT studies is to prepare a feasibility report. Detailed project report (DPR) should be prepared after completing all the detailed studies including final location survey, preparation of cross sections, soil and material surveys etc. Design details of the pavements & all structures should be carried out & the relevant drawings prepared as specified in the terms of reference for the project preparation.

— : Highway Development & Planning :—

⇒ Historical Development of Road Construction :—
(ORDER OF ROAD DEVELOPMENT)

1. Roman Roads :-

i) First time Roman started Construction of Roads in large scale.

ii) In 312 BC, they Constructed "Appian way" of length over 580 km.

Layers of Roman Roads —

1. Large foundation stones in Lime mortar (10 to 20 cm thick)
2. Broken stones in Lime mortar (25 to 40 cm thick)
3. Lime Concrete (25 to 40 cm thick)
4. Large stone slabs in Lime mortar (10 to 15 cm. thick)

Total thickness — 0.75 to 1.2 m.

Main Features of Roman Roads —

i) They were built straight regardless of gradient.

ii) Total thickness was as high as 0.75 to 1.2 m.

iii) The wearing Course Consisted of large dressed stone blocks in lime mortar.

2. Tresaguet Construction :-

i) "Pierre Tresaguet" (1716-1796) developed an improved method of Road Construction by the year 1964 A.D.

Layers of Tresaguet Construction —

i) Large foundation stone on Edge, 17 cm. Thick.

ii) Broken stones, 8 cm Thick.

iii) Sloping wearing surface, 5 cm thick.
(Slope - 1 in 45)

Total thickness = 30 cm.

Main features of Tresaguet Construction –

i) The thickness was of the order of 30 Cm.

ii) Consideration was given to Subgrade moisture and drainage of surface water.

iii) Shoulder sloping was provided of order of 1 in 20.

3. Metcalf Construction :–

i) "John Metcalf" was working in England during the period of "Tresaguet".

ii) He followed the recommendation of "Robert phillips" and was responsible for Construction of about 290 Km. of road in the northern region of England.

4. Telford Construction :–

i) "Thomas Telford", founder of Institution of Civil Engineering at London, began his work in early 19th Century.

Layers of Telford Construction –

i) Foundation stones of varying size (17 - 22Cm)

ii) Broken stone in Lime mortar at the edge (15 Cm thick) + Two layers of Angular Broken stone (7Cm size) ~~10Cm thick~~ (10Cm & 5Cm thickness)

iii) Binding layer of wearing Course 4 Cm thick with Cross slope of 1 in 45.

Main features of Telford Construction :–

i) In this Construction leveled Subgrade of width 9m. was provided.

ii) Wearing Course slope of about 1 in 45.

5. Macadam Construction :-

i) "John Macadam", Surveyor General of Roads in England, put forward an entirely new method of road Construction.

ii) This was the first method based on Scientific thinking.

iii) This new Concept came in the year 1827.

Construction steps -

i) Subgrade is Compacted and prepared with a cross slope of 1 in 36 upto a desired width of 9m.

ii) Broken stones, all passing through 5 cm sieve size were Compacted to a uniform thickness of 10 cm.

iii) The 2nd layer of broken stone of size 3.75 cm was Compacted to thickness of 10 cm.

iv) The top layer Consisted of stones of size less than 2cm. Compacted to a thickness of about 5 cm and maintaining the slope of about 1 in 36.

Main features are -

i) Importance was given to subgrade drainage and Compaction so that Subgrade was compacted and prepared with cross Slope of 1 in 36.

ii) The Size of broken stone for top layers was decided on the basis of stability under animal drawn vehicles.

iii) The thickness of each layer was kept uniform from edge to the Centre. and the total thickness also kept uniform to a minimum value of 25 cm.

iv) The pavement Surface was also given the cross slope of 1 in 36.

⇒ Comparison Between Macadam & Telford Method :-

Macadam Method	Telford Method.
i) The subgrade was given a cross slope of 1 in 36 to facilitate subgrade drainage.	i) The subgrade was kept horizontal and hence subgrade drainage was not proper.
ii) The bottom layer of pavement or the sub-base course consisted of broken stones of less than 5 cm size to uniform thickness of 10 cm. only.	ii) Heavy foundation stones of varying sizes, about 17 cm towards the edge and 22 cm towards the centre were hand packed and prepared to serve as sub-base course.
iii) Base and surface courses consisted of broken stones of smaller sizes to compacted thickness of 10 cm & 5 cm. respectly and top surface was given a cross slope of 1 in 36.	iii) Two layers of broken stones were compacted over the foundation stones before laying the wearing course of thickness 4 cm with slope 1 in 45.
iv) The total thickness of pavement was kept uniform from edge to the centre to a minimum value of 25 cm. only.	iv) The total thickness of construction varied from about 35 cm at the edge to about 41 cm. at the centre.

⇒ Highway Development in India :-

1. Jayakar Committee and the Recommendations —

i) A resolution was passed by both chambers of Indian legislature in 1927, in response to which "Jayakar committee" was constituted with "M.R. Jayakar" as chairman.

Recommendations by the Committee

i) The road development in Country should be Considered as a national interest as this has become beyond the Capacity of provincial government and local bodies.

ii) An extra tax should be levied on petrol from the road users to develop a road development fund Called "Central Road fund".

iii) A Semi official ~~the~~ technical body should be formed to pool technical know how from various parts of the Country and to act as an advisory body on various aspects of roads.

iv) A Research organisation should be instituted to carry out research and development work and to be available for consultations.

Most of the "Jayakar Committee" Recommendations were accepted and following steps were taken —

i) The "Central Road Fund" was formed by the year 1929.

~~ii) A semi technical body~~

ii) A Semi official technical body named as "Indian Road Congress" was formed in 1934.

iii) "Motor Vehicle Act" was started in 1939 to regulate the road traffic in the form of traffic laws, ordinances and regulations. and later on it has been revised in the year 1988.

iv) A research organisation named as "Central Road Research Institute" (CRRI) was formed in 1950 at New Delhi. for research in various aspects of highway engineering.

Other Measures are taken as following -

i) National Highway Act :-

⇒ This act was passed in the year 1956.

⇒ Main features of this act are —

i) The responsibility of development and maintenance of the national highway (NH) to be provisionally taken by the Central govt.

ii) The Central government to be empowered to declare any other highway as NH or to omit any other existing national highway from the list.

ii) "Highway research board" was setup in 1973, with view to give proper direction and guidance to road research activities in India.

iii) The "National Transport policy Committee" (NTPC) was setup in 1978

* IRC (Indian Road Congress) has played important role in formulation of the last three 20 years road development plans in India.

Road plans :-

A. First 20 years Road plan (Nagpur Road plan) - (1943-63)

Features :-

i) The Nagpur Road plan formulae were prepared on the basis of "star and grid" pattern.

ii) The total road length of 5,32,700 Km with a density of 16 Km of road length per 100 Km^2 area would be available by the year 1963.

iii) All roads are classified into 5 Categories - NH, SH, MDR ODR, VR.

[NH - National Highways, SH - State Highways
MDR - Major District Roads, ODR - Other District Roads
VR - Village Roads.]

iv) Length of railway track in the area was considered within the total road length.

Result – Though total achievement was higher than the targeted value, but the length of NH & SH achieved were lesser than the targeted value.

B. Second 20 years Road plan (Bombay Road plan) (1961-81)

Features of this plan are –

i) At the ends of the plan, the target road length aimed was 32 Km per 100 Km^2 Area.

ii) Maximum distance of any place in a developed or agricultural area would be 6.4 Km. from a metalled road and 2.4 Km from any Category of Roads.

iii) Every town with a population above 2000 in plains and above 1000 in Semi hill areas and above 500 in hilly areas should be connected by metalled Road.

iv) 1600 Km. Express ways have been Considered in this plan within proposed target of NH.

v) A development factor of 5% is provided for future development.

Result

i) Total achievement was higher than the targeted but NH and SH were Constructed lesser than targeted.

ii) It should be noted that allowance for development of agriculture and industry during the next 20 yrs was made in Nagpur plan allowing 15% increase in the Calculated road length. This allowance is 5% only according to 2nd plan.

C. Third 20 year Road plan (Lucknow Road plan) (1981-2001)

i) In this plan, Roads are classified into 3 road system.
   a) primary road system.
   b) Secondary road system.
   c) Tertiary road system.

ii) The overall road density was targeted as 82 Km/100 Km² area.

iii) The NH network should be expanded to form square grids of 100 Km. Sides so that no part of the country is more than 50 Km. away from a NH.

iv) Express ways should be constructed along major traffic Corridors to provide fast travels.

v) There should be improvement in enviromental quality and road safety.

A. Primary Road System —

This Road System includes

i) Express ways of total length 2000 Km.

ii) NH based on the Concept of 100 Km. Square grids. 100 + 100 = 200 Km. of NH length are provided per 100 × 100 = 10000 Km² area (i.e, 1 Km/50 Km² area)

According to this Concept Total length of NH in the country = 66000 Km.

B. Secondary Road System —

This Road System includes,

i) State Highway (SH)

ii) Major district Road (MDR)

State highway (SH) —

dej

✓ Length of SH in Km. = $\left[\frac{\text{Area of state (Km}^2\text{)}}{25}\right]$ or $\left[\frac{62.5 \times \text{no. of towns in state}}{\text{Total area of state}}\right]$

✓ Length of NH in Km = $\left[\frac{\text{Total area of state}}{50}\right]$ − Length of NH

Major District Road (MDR) :-

✓ Length of MDR in Km = $\frac{\text{Area of state } (Km^2)}{12.5}$ or

= 90 X No. Of towns in state.

C. Tertiary Road System -

This road System includes ,

i) other district roads (ODR)

ii) Village Roads (VR)

CLASSIFATION OF ROADS :-

1. Depending on weather / season.
   a) All weather roads
   b) Fair weather roads
2. Based on type of Carriage way
   a) paved Road - provided with a hard pavement Course e.g., WBM (water Bound Macadum) etc.
   b) unpaved Road - provided w/o a hard pavement Course. e.g., Earth, gravel road etc.
3. Based on type of pavement Surfacing
   a) Surface Road. (Bituminous or Cement Conc. surfacing)
   b) unSurface Road
4. Based on traffic volume
   a) Heavy traffic Road
   b) Medium traffic Road
   c) Light traffic Road.
5. Based on location & function as per Nagpur road plan
   a) National highway (NH) - Main highway running across Country.
   b) state highway (SH) - Arterial road of a state Connecting with the NH of adjacent state
   c) Major District Road d) Other district Road.
   e) Village Road.

ROAD PATTERNS :—

a) Rectangular or Block pattern (Adopted in Chandigarh)
b) Radial or star and Block pattern
c) Radial & Circular pattern (Adopted at Connaught place of Delhi)
d) Radial & Grid — (Adopted in Nagpur road plan)
e) Hexagonal pattern
f) Minimum travel pattern.

BASIC REQUIREMENTS OF IDEAL ALIGNMENT :—

(i) Short
(ii) Easy
(iii) Safe
(iv) Economy.

FACTORS CONTROLLING ALIGNMENT :-

(i) obligatory points — These are control points governing the alignment of highway.
(ii) Traffic
(iii) Geometric design
(iv) Economics
(v) Stability
(vi) Drainage
(vii) Resisting length.

PLANNING SURVEYS :-

For assessing the road length requirements, following studies are made -

(i) Economic Studies
(ii) Financial Studies
(iii) Traffic or road use studies
(iv) Engineering Studies.

ENGINEERING SURVEYS FOR HIGHWAY LOCATION :-

Before highway alignment is finalized in highway project, the Engineering Surveys are to be carried out.

The stages of Engineering Surveys are —

a) Map study

i) Topographic maps are available from the Survey of India with 15 to 30 m. Contour intervals.

ii) Valley, ponds or lakes etc. Can be avoided and approximate position of bridges etc. Can be planned

b) Reconnaissance — This is used to examine the general character of the area for deciding most feasible routes for detailed studies.

c) preliminary Survey -

i) This is carried out to collect all physical information which are necessary in Connection with the proposed highway alignment.

ii) This work Consist of
- primary traverse
- Topographical features
- Levelling work
- Drainage studies & hydrological data.
- Soil Survey
- Material Survey
- Determinations of final centre line.

d) Final location & Detail Survey -

i) The Centre line of road finalized is translated on the ground during location Survey.

ii) Detailed Survey is done to fix temporary bench mark and levelling work is done for drainage & earthwork Calculations.

Depends on weather condition

Should follow the flight rules.

JAYAKAR COMMITTEE RECOMMENDATIONS AND IMPLEMENTATION

RECOMMENDATIONS: Over a period after the First World War, motor vehicles using the roads increased and this demanded a better road network which can carry mixed traffic conditions. The existing roads when not capable to withstand the mixed traffic conditions. For the improvement of roads in India government of India appointed Mr. Jayakar Committee to study the situations and to recommend suitable measures for road improvement in 1927 and a report was submitted in 1928 with following recommendations:

Road development in the country should be considered as a national interest. As the provincial and local government do not have the financial and technical capacity for road development.

Extra tax to be levied from the road users as fund to develop road.

A Semi-official technical body has to be formed to collect and pool technical knowhow from various parts of the country and to act as an advisory body on various aspects of the roads.

A research organization should be instituted at National level to carry out research and

development work and should be available for consultation.

IMPLEMENTATIONS:

Majority of the recommendations were accepted by the government implemented by Jayakar Committee.

Some of the technical bodies were formed such as,

- Central Road Fund (CRF) in 1929

- Indian Road Congress (IRC) in 1934
- Central Road Research Institute (CRRI) in 1950.

Central Research Fund (CRF):

Central Research Fund (CRF) was formed on 1st March 1929

The consumers of petrol were charged an extra levy of 2.64 paisa/litre of petrol to buildup this road development fund.

From the fund collected 20 percent of the annual revenue is to be retained as meeting expenses on the administration of the road fund, road experiments and research on road and bridge projects of special importance.

The balance 80 percent of the fund to be allotted by the Central Government to the various states based on actual petrol consumption or revenue collected

The accounts of the CRF are maintained by the Accountant General of Central Revenues.

The control of the expenditure is exercised by the Roads Wings of Ministry of Transport.

Indian Road Congress (IRC):

It s a semi -official technical body formed in 1934.

It was formed to recommend standard specifications.

It was constituted to provide a forum of regular technical pooling of experience and ideas on all matters affecting the planning, construction and maintenance of roads in India.

IRC has played an important role in the formulation of the 20-year road development plans in India.

Now, it has become an active body of national importance controlling

specifications, guidelines and other special publications on various aspect of Highway Engineering.

Central Road Research Institute (CRRI):

CRRI was formed in the year 1950 at New Delhi

It was formed for research in various aspect of highway engineering

It is one of the National laboratories of the Council of Scientific and Industrial Research.

This institute is mainly engaged in applied research and offers technical advice to state governments and the industry on various problems concerning roads.