

# HIGHWAY ENGINEERING

## CV0503

### CHAPTER-1: INTRODUCTION TO HIGHWAY ENGINEERING

#### Course Overview:

Highways are the corner stone of any country's infrastructure. The size and quality of highway networks decide the degree and scale of any nation's development.

Many graduates of civil engineering departments find many job opportunities in highway construction projects. Therefore the subject of highway engineering constitutes a major topic at civil engineering departments. The subject is given to the third year students. A basic knowledge in mathematics, trigonometric geometry, and surveying is required.

#### Course Objective

**The objectives of this course are to enable the students to follow the concept of Importance of transportation, Different modes of transportation, Characteristics of Road Transport, Scope of highway Engineering. This goal is achieved through the introduction of the following topics:**

- Importance of transportation
- Different modes of transportation
- Characteristics of Road Transport
- Scope of highway Engineering.

#### What is Highway Engineering?

Highway engineering is an engineering discipline branching from civil engineering that involves the planning, design, construction, operation, and maintenance of roads, bridges, and tunnels to ensure safe and effective transportation of people and goods.

#### Why are highways so important?

Highways are vitally important to a country's economic development. The construction of a high quality road network directly increases a nation's economic output by reducing journey times and costs, making a region more attractive economically. The actual construction process will have the added effect of stimulating the construction market.

#### 1.0 Importance of transportation

Highway transportation is the means of detail distribution between homes, shops, factories etc. It is only the roads which can carry goods from and to aero drums, harbours and railway station

The utility of roads anywhere in the different parts of a country, they can be rightly compared to arterials in a human body.

Just as arteries maintain man's health by providing circulation of blood, similarly Roads promote nation's wealth by keeping it's people and goods moving. Thus, we see that progress and well-being of a nation depends much on roads. In fact, roads are the life lines of nation's economy.

## **2.0 Scope of highway Engineering**

Apart from the design, construction and maintenance of different types of roads, highway engineering also includes the study of the following topics.

- 2.1 **Development planning and locations of roads:** Historical background, Basis for planning, Master plan, Engineering surveys and Highway alignment.
- 2.2 **Highway design, Geometrics and structures:** Road geometrics and their design, Rigid and Flexible pavements, Design factors and thickness design, Overlay design, Design of drainage system.
- 2.3 **Highway traffic performance and its control:** Traffic study analysis, Need for new road link, Traffic regulation and control, intersection design and their controls with signs, signals, islands and markings
- 2.4 **Materials, Construction and Maintenance:** Highway materials and mix design, Highway construction, Earth work, construction of different types of pavements, maintenance of pavements and drainage system.
- 2.5 **Economics, Finance and Administration:** Road user cost and economic analysis of highway projects, Pavement types and maintenance measures, Highway finance and phasing of expenditures.

## **3.0 Different modes of transportation**

Mode of transport is a term used to distinguish substantially different ways to perform transport. The most dominant modes of transport are aviation, land transport, which includes rail, road and off-road transport, and ship transport. Other modes also exist, including pipelines, cable transport, and space transport.

### **Types of transportation**

1. Air
2. Land
  - Rail
  - Road
  - Water
3. Other modes

### **3.1 Air Transport**

Air transport though new as compared to other modes of transportation, has gained large popularity in transporting various commodities. The basic advantage of Air transport is its high speed. By air, the time required may be just a few hours, which may be days by other modes of transport. However this being a major advantage, air transport also has various disadvantages. These are:

- Air transport is a costly affair.
- Air transport is limited by 'lift capacity' i.e. goods upto certain load (weight) can be transported by aircrafts.

### 3.2 Road Transport

Road transport forms an essential part of any transport activity, whether rail, sea or air. It is essential as a supplementary and complementary mode of transport to complete movement by other modes of transport. Eg. From one terminal i.e. the railway station the goods have to be carried to the destination by road.

Highway transportation has increased rapidly since the end of World War II. This is because Motor carrier industry results from door-to-door operating flexibility and speed of intercity movement. They are even flexible because they can operate on each and every kind of roadways.

In comparison to railroads, motor carriers have relatively small fixed investments in terminal facilities and operate on publicly maintained highways.

The variable cost per mile for motor carriers is high because a separate power unit and driver are required for each trailer or combination of tandem trailers. Labor requirements are also high because of driver safety restrictions and the need for substantial dock labor. Motor carriers are best suited to handle small shipments moving short distances.

Since 1980, the industry segments have become more definitive since deregulation, and include truckload (TL), less than truckload (LTL), and specialty carriers. TL segment includes loads over 15,000 pounds that generally do not require intermediate stops for consolidation. LTL segment of the industry loads less than 15,000 pounds that generally requires stops at intermediate terminals for consolidation. Because of terminal costs and relatively higher marketing expenses, LTL experiences a higher percentage of fixed costs than TL.

In short Road transport offers certain advantages like

- Door to door service to customers which neither rail nor neither sea nor air transport can offer.
- On per unit basis, the cost of making a road is 1/6<sup>th</sup> that of laying a railway line.
- Capital investment in case of railways is much less than railways designed to carry equivalent quantum of traffic.
- Road transport provides employment to many people.

Road transport faces a number of problems. This is evident from the following facts:

- There is an occasional storage of diesel fuel in the country.
- Vehicle availability in the country has been problematic. With the recent entry of a number of manufacturers, the situation has improved to some extent.
- The cost of components and accessories, such as tyres and batteries, has escalated tremendously.
- The present Motor Vehicle Act regulating the issue of licenses and permits and movement of vehicles is very restrictive.
- Conditions on Indian road are very bad and hazardous. They tend to reduce speed of vehicles, which leads to wastage of natural transport capacity.

### **3.3 Rail**

India has amongst the largest railway network in the world. Every city, town, village has a rail connection. Through railways very large volumes of goods can be transported economically over long distances to remote places in the country. But railways in general incur high fixed costs because of expensive equipment switching yards and terminals. However the railways experience relatively low variable operating costs. Railways help to transport raw materials from extractive industries which are located at considerable distances. Besides this railways also transport massive amount of steel, automobiles, war equipment, across the country.

Railroads basically concentrate on the container traffic and are becoming more responsive of the customer needs, emphasizing bulk industries and heavy manufacturing. They have expanded their intermodal operations through alliances and motor carrier ownership. Railroads are even concentrating on development of special equipment. There are unit trains which are entire train carrying the same commodity, which are bulk products such as coal or grain. Unit trains are faster, less expensive to operate and quick as it can bypass rail yards and go direct to the product's destination.

There are also various different types, such as articulated cars for extended Rail chassis, double-stack railcars, have 2 levels of containers, thereby doubling the capacity of each car. It also reduces chances of damage because of their design. These technologies have are being applied by railroads to reduce weight, increase carrying capacity, and facilitate interchange.

### **3.4 Water transport**

One of the oldest modes of transportation is water. In terms of time factor, they may be slow. But, they Water transport could be of inland can carry more shipment, at reduced cost over longer distance. Water transport could be of inland type or oceanic transport.

#### **3.4.1 Inland water transport**

Inland water transport is used mainly for transport within a country. In our country Inland water transport through rivers and canals is quite popular because of the low cost and bulk transport. But here, the inland water transport system heavily depends upon the rain and in many places on the tides. So, in our country we cannot guarantee the functioning of inland water throughout the year at the same efficiency.

#### **3.4.2 Oceanic Transport**

Oceans act as huge waterways for transport of goods from one country to another. Oceanic transportation includes import and export of crude and bulky commodities like materials which are removed from mines, cement, chemical, crude oil, iron ore, coal, chemicals like sulphur, crude petroleum, and selected agricultural products, etc.

The capability of water to carry large tonnage at low variable costs makes it in demand. When a company desire low freight rates and the speed and the time of transport are secondary, it has the option of selecting water as a mode of transport.

The main disadvantage of water transport is the limited range of operation and speed.

### **3.5 Pipelines**

Primarily, pipeline is used for the transport of crude petroleum, refined petroleum and natural gas. Pipelines are also used for the transportation of certain types of chemicals, Pulverized dry bulk materials such as cement and flour via hydraulic suspension system, and sewage and water in cities.. E.g.: pipeline may be best suited to transport crude petroleum from the port to the refinery. But, to transport refined petrol to a gas station does not justify the use of a pipeline and this is better done by a truck. There is a talk going on between India, Iran and Pakistan regarding the transportation of crude oil from Iran to India with the help of a pipeline which will pass through Pakistan. This will reduce the cost of transporting crude oil from Iran to India.

In comparison with the other modes of transport, pipelines operate on a 24 hour basis, seven days a week. They stop functioning due to change in the commodity to be transported, or due to maintenance. Unlike other modes of transport, pipeline does not have any 'empty containers' or vehicles' which are to be returned to the origins.

### **3.6 Rope ways**

A ropeway is a form of naval lifting device used to transport light stores and equipment across rivers or ravines. It comprises a jackstay, slung between two sheers or gyps, one at either end, from which is suspended a block and tackle, that is free to travel along the rope and hauled back and forth by inhauls (ropes attached to the pulley from which the block and tackle are suspended).

### **4.0 Characteristics of Road Transport**

- They are cheaper
- Roads are used by various types of road vehicles like passenger cars, buses, trucks etc.
- It requires a small investment for the government. Construction & maintenance of road is cheaper than other modes.
- Road transport offers a complete freedom to road users to transfer the vehicle from one lane to another & also flexibility of changes in location, direction, speed & timings are not available in other modes.
- Road transport saves time.
- Speed of movement is directly related with the severity of accident. The road safety decreases with increasing dispersion of speed. Road transport is subjected to severity of high degree of accidents due to flexibility movements.
- Road transport is the only means of transport that offers itself to the whole community

## **CHAPTER-2: HIGHWAY DEVELOPMENT & PLANNING**

### **What is Highway Engineering?**

Highway engineering is an engineering discipline branching from civil engineering that involves the planning, design, construction, operation, and maintenance of roads, bridges, and tunnels to ensure safe and effective transportation of people and goods.

### **Why are highways so important?**

Highways are vitally important to a country's economic development. The construction of a high quality road network directly increases a nation's economic output by reducing journey times and costs, making a region more attractive economically. The actual construction process will have the added effect of stimulating the construction market.

### **Course Overview**

Road transport is one of the most common mode of transport. Roads in the form of trackways, human pathways etc. were used even from the pre-historic times. Since then many experiments were going on to make the riding safe and comfort. Thus road construction became an inseparable part of many civilizations and empires. In this chapter we will see the different generations of road and their characteristic features. Also we will discuss about the highway planning in India.

### **Course Objectives:**

The objectives of this course are to enable the students to follow the concept of Historical Development Of Road Construction, Highway Development in India, Classification of Roads, Planning Surveys, Interpretation of planning surveys. This goal is achieved through the introduction of the following topics:

- Historical Development Of Road Construction
- Highway Development in India
- Classification of Roads
- Planning Surveys
- Interpretation of planning surveys.

### **Important technical terms related to roads:**

1. Road: A public thorough fare over which vehicles, cyclists, pedestrians etc. may lawfully move from one place to another is called a road or highway.

Usually, the term highway is used for an important road of national or state importance in a country.

2. Traffic: The vehicles, cycles, carts, pedestrians etc. travelling together on a road constitute the traffic.

3. Foot way: The portion of roadway of an urban road reserved only for pedestrians is called foot path or side walk. The minimum width of side walk should be 1.5 m.

4. Cycle track: The portion of roadway of an urban road reserved only for bicycles is called cycle track.

The minimum width of cycle track should be 2 metres.

5. Motor way: The portion of roadway of an urban road reserved for use only by high speed and power driven vehicles is called motor way, express way.

#### **Objects of highway planning:**

- To plan a road network for efficient and safe traffic operation, but at minimum cost. Here the costs of construction, maintenance and renewal of pavement layers and the vehicle operation costs are to be given due consideration.
- To arrive at the road system and the lengths of different categories of roads which could provide minimum utility and could be constructed within the available resources during the plan period under consideration.
- To fix up date wise priorities for development of each road link based on utility as the main criterion for phasing the road development programme.
- To plan for future requirements and improvements of road in view of predicted developments.
- To work out financing system.

### **1.0 Historical Development of Road Construction**

The history of highway engineering gives us an idea about the roads of ancient times. Roads in Rome were constructed in a large scale and it radiated in many directions helping them in military operations. Thus they are considered to be pioneers in road construction. In this section we will see in detail about Ancient roads, Roman roads, British roads, French roads etc.

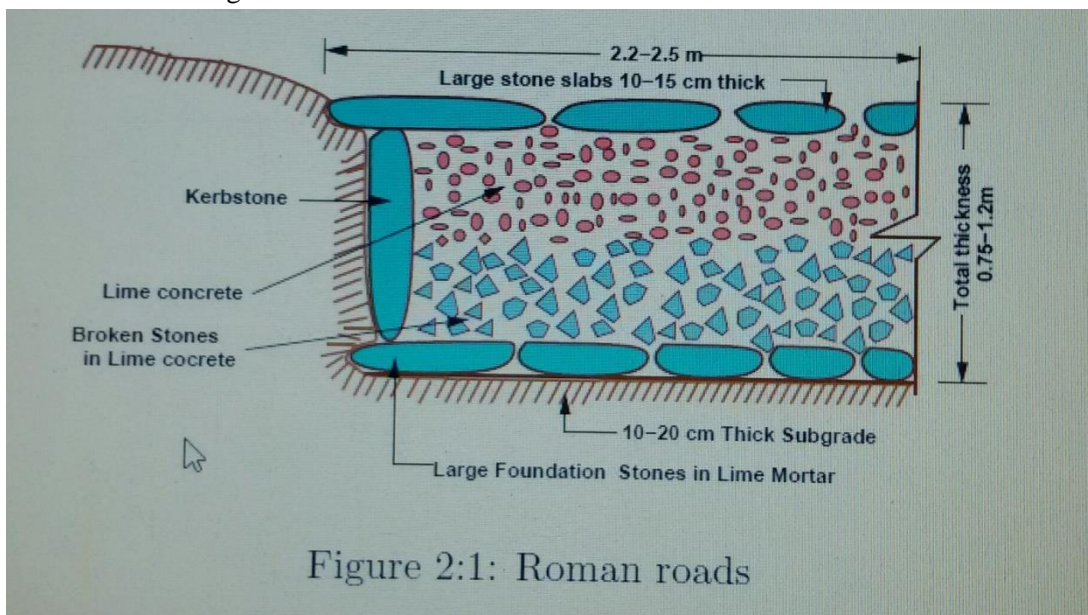
#### **1.1 Ancient Roads**

The first mode of transport was by foot. These human pathways would have been developed for specific purposes leading to camp sites, food, streams for drinking water etc. The next major mode of transport was the use of animals for transporting both men and materials. Since these loaded animals required more horizontal and vertical clearances than the walking man, track ways emerged. The invention of wheel in Mesopotamian civilization led to the development of animal drawn vehicles. Then it became necessary that the road surface should be capable of carrying greater loads. Thus roads with harder surfaces emerged. To provide adequate strength to carry the wheels, the new ways tended to follow the sunny drier side of a path. These have led to the development of foot-paths. After the invention of wheel, animal drawn vehicles were developed and the need for hard surface road emerged. Traces of such hard roads were obtained from various ancient civilization dated as old as 3500 BC. The earliest authentic record of road was found from Assyrian empire constructed about 1900 BC.

##### **1.1.1 Roman roads**

The earliest large scale road construction is attributed to Romans who constructed an extensive system of roads radiating in many directions from Rome. They were a remarkable

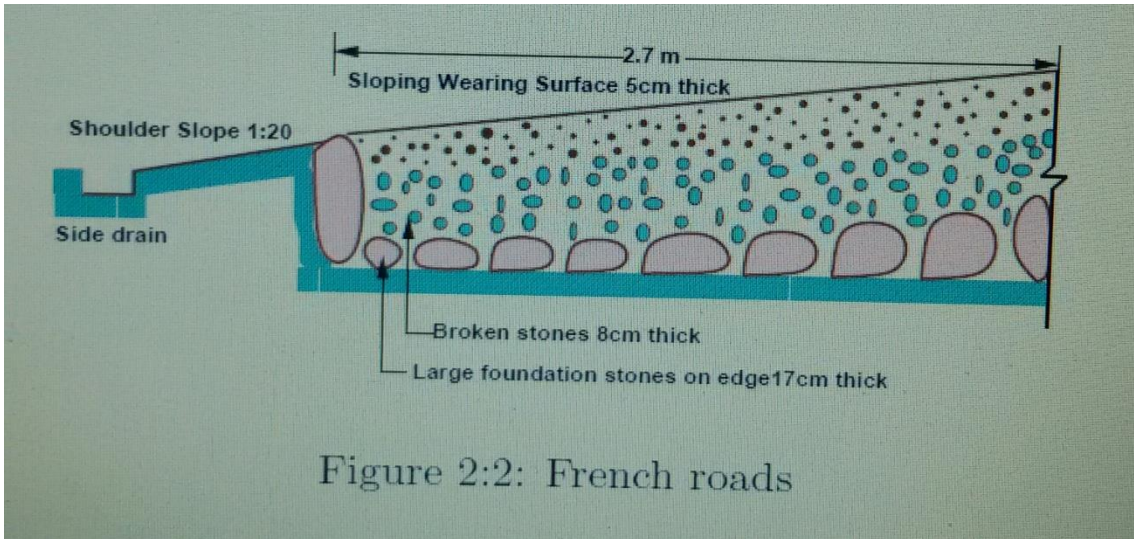
achievement and provided travel times across Europe, Asia minor, and north Africa. Romans recognized that the fundamentals of good road construction were to provide good drainage, good material and good workmanship. Their roads were very durable, and some are still existing. Roman roads were always constructed on a firm-formed subgrade strengthened where necessary with wooden piles. The roads were bordered on both sides by longitudinal drains. The next step was the construction of the agger. This was a raised formation up to a 1 meter high and 15 m wide and was constructed with materials excavated during the side drain construction. This was then topped with a sand leveling course. The agger contributed greatly to moisture control in the pavement. The pavement structure on the top of the agger varied greatly. In the case of heavy traffic, a surface course of large 250 mm thick hexagonal flag stones were provided. A typical cross section of roman road is given in Figure 2:1 The main features of the Roman roads are that they were built straight regardless of gradient and used heavy foundation stones at the bottom. They mixed lime and volcanic puzzolana to make mortar and they added gravel to this mortar to make concrete. Thus concrete was a major Roman road making innovation.



### 1.1.2 French roads

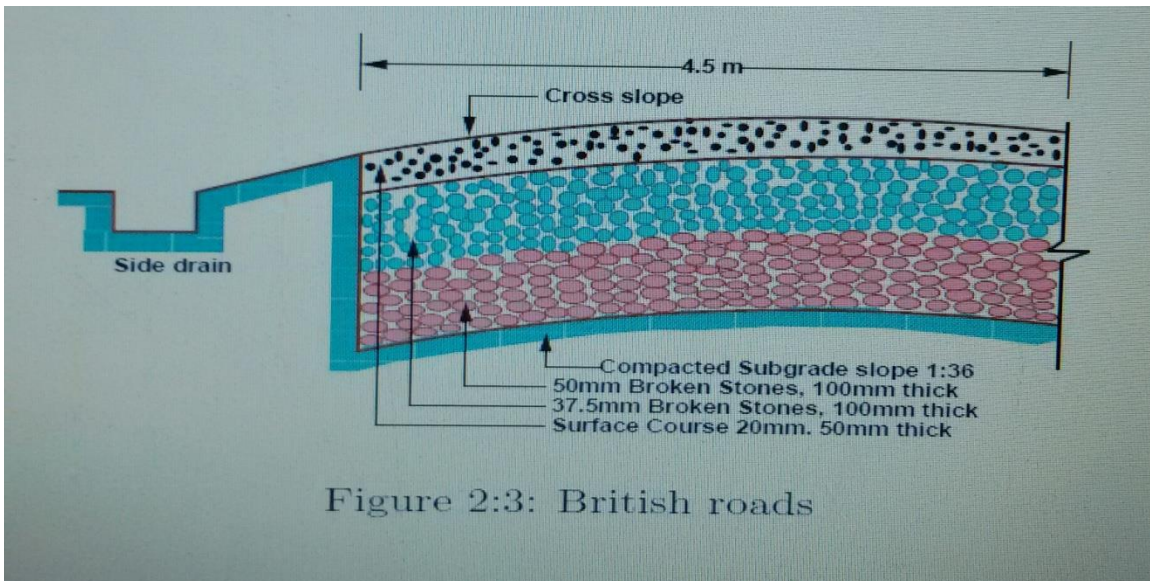
The next major development in the road construction occurred during the regime of Napoleon. The significant contributions were given by Tresaguet in 1764. He developed a cheaper method of construction than the lavish and locally unsuccessful revival of Roman practice. The pavement used 200 mm pieces of quarried stone of a more compact form and shaped such that they had at least one flat side which was placed on a compact formation. Smaller pieces of broken stones were then compacted into the spaces between larger stones to provide a level surface. Finally the running layer was made with a layer of 25 mm sized broken stone. All this structure was placed in a trench in order to keep the running surface level with the surrounding country side. This created major drainage problems which were counteracted by making the surface as impervious as possible, cambering the surface and providing deep side ditches. He gave much importance for drainage. He also enunciated the necessity for continuous organized maintenance, instead of intermittent repairs if the roads were to be kept usable all times. For this he divided the roads between villages into sections of such length that an entire road could be covered by maintenance men living nearby.





### 1.1.3 British roads

The British government also gave importance to road construction. The British engineer John Macadam introduced what can be considered as the first scientific road construction method. Stone size was an important element of Macadam recipe. By empirical observation of many roads, he came to realize that 250 mm layers of well compacted broken angular stone would provide the same strength and stiffness and a better running surface than an expensive pavement founded on large stone blocks. Thus he introduced an economical method of road construction.



### 1.2 Modern roads

The modern roads by and large follow Macadam's construction method. Use of bituminous concrete and cement concrete are the most important developments. Various advanced and cost-effective construction technologies are used. Development of new equipments help in the faster construction of roads. Many easily and locally available materials are tested in the laboratories and then implemented on roads for making economical and durable pavements. Scope of transportation system has developed very largely. Population of the country is increasing day by day. The life style of people began to change. The need for travel to various places at faster speeds also increased. This increasing demand led to the emergence of other modes of transportation like railways and travel by

air. While the above development in public transport sector was taking place, the development in private transport was at a much faster rate mainly because of its advantages like accessibility, privacy, flexibility, convenience and comfort. This led to the increase in vehicular traffic especially in private transport network. Thus road space available was becoming insufficient to meet the growing demand of traffic and congestion started. In addition, chances for accidents also increased. This has led to the increased attention towards control of vehicles so that the transport infrastructure was optimally used. Various control measures like traffic signals, providing roundabouts and medians, limiting the speed of vehicle at specific zones etc. were implemented. With the advancement of better roads and efficient control, more and more investments were made in the road sector especially after the World wars. These were large projects requiring large investment. For optimal utilization of funds, one should know the travel pattern and travel behavior. This has led to the emergence of transportation planning and demand management.

## **2.0 Highway Development in India:**

Excavations in the sites of Indus valley, Mohenjo-dero and Harappan civilizations revealed the existence of planned roads in India as old as 2500-3500 BC. The Mauryan kings also built very good roads. Ancient books like Arthashastra written by Kautilya, a great administrator of the Mauryan times, contained rules for regulating traffic, depths of roads for various purposes, and punishments for obstructing traffic.

During the time of Mughal period, roads in India were greatly improved. Roads linking North-West and the Eastern areas through gangetic plains were built during this time.

After the fall of the Mughals and at the beginning of British rule, many existing roads were improved. The construction of Grand-Trunk road connecting North and South is a major contribution of the British. However, the focus was later shifted to railways, except for feeder roads to important stations.

### **2.1 Modern developments:**

The First World War period and that immediately following it found a rapid growth in motor transport. So need for better roads became a necessity. For that, the Government of India appointed a committee called Road development Committee with Mr. M.R Jayakar as the chairman. This committee came to be known as Jayakar committee.

### **2.2 Jayakar Committee:**

In 1927 Jayakar committee for Indian road development was appointed. The major recommendations and the resulting implementations were:

- Committee found that the road development of the country has become beyond the capacity of local governments and suggested that Central government should take the proper charge considering it as a matter of national interest.
- They gave more stress on long term planning programme, for a period of 20 years (hence called twenty year plan) that is to formulate plans and implement those plans within the next 20 years.
- One of the recommendations was the holding of periodic road conferences to discuss about road construction and development. This paved the way for the establishment of a semi-social technical body called Indian Road Congress (IRC) in 1934
- The committee suggested imposition of additional taxation on motor transport which includes duty on motor spirit, vehicle taxation and license fees for vehicles plying for hire. This led to the introduction of a development fund called Central road fund in 1929. This fund was intended for road development.

- A dedicated research organization should be constituted to carry out research and development work. This resulted in the formation of Central Road Research Institute (CRRI) in 1950.

### **2.2.1 Nagpur road plan (First 20-year Road plan 1943-1963):**

The second World War saw a rapid growth in road traffic and this led to the deterioration in the condition of roads. To discuss about improving the condition of roads, the government convened a conference of chief engineers of provinces at Nagpur in 1943. The result of the conference is famous as the Nagpur plan.

- A twenty year development programme for the period (1943-1963) was finalized. It was the first attempt to prepare a co-ordinated road development programme in a planned manner.
- 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.
- The committee planned to construct 2 lakh kms of road across the country within 20 years.
- They recommended the construction of star and grid pattern of roads throughout the country.
- One of the objective was that the road length should be increased so as to give a road density of 16kms per 100 sq.km .

### **2.2.2 Bombay road plan (Second 20-year road plan 1961-1981):**

The length of roads predicted under the Nagpur plan was achieved by the end of it, but the road system was deficient in many respects. 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:

- It was the second 20 year road plan (1961-1981)
- The total road length targeted to construct was about 10 lakhs.
- Rural roads were given specific attention. Scientific methods of construction was proposed for the rural roads. The necessary technical advice to the Panchayaths 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.

### **2.2.3 Lucknow road plan (Third 20-year road plan 1981-2001):**

This plan has been prepared keeping in view the growth pattern predicted in various fields by the turn of the century. Some of the salient features of this plan are as given below:

- This was the third 20 year road plan (1981-2001). It is also called Lucknow road plan.

- It aimed at constructing a road length of 12 lakh kilometres 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.

### **3.0 Classification of Roads:**

#### **3.1 Types of roads:**

1. Classification based on weather:
  - All weather roads: All weather roads are those which are negotiable during all weather, except at major river crossings where interruption to traffic is permissible upto a certain extent, the road pavement should be negotiable during all weathers.
  - Fair-weather roads: Fair weather roads are which the traffic may be interrupted during monsoon season at causeways where streams may overflow across the road.
2. Classification based on the type of carriage way:
  - Paved roads: If they are provided with a hard pavement course which should be at least a water bound macadam (WBM) layer.
  - Unpaved roads: If they are not provided with a hard pavement course which should be at least a water bound macadam (WBM) layer. Thus earth roads and gravel roads may be called unpaved roads.
3. Classification based on type of pavement surface:
  - Surface roads: Which are provided with a bituminous or cement concrete surfacing.
  - Un-surfaced roads: Which are not provided with a bituminous or cement concrete surfacing.

#### **3.2 Methods of classification of roads:**

The roads are generally classified as

- Traffic volume: The roads are classified as Heavy, Medium and Light traffic roads.
- Load transported or tonnage: The roads are classified as class I, class II or class A or class B etc. And the limits may be expressed as tonnes per day.
- Location and function:

##### **3.2.1 Classification of Roads by Nagpur Road plan:**

The Nagpur Road Plan classified the roads in India based on location and function into five categories.

- National Highways (NH)
- State Highways (SH)
- Major District Roads (MDR)

- Other District Roads (ODR)
- Village Roads (VR)

**National Highways (NH):** National Highways are main highways running through the length and breadth of India, connecting major ports, foreign highways, capitals of large state and large industrial and tourists centres including roads required for strategic movements for the defence of India.

- NH-44 Srinagar- delhi- jhansi- nagpur- Hyderabad- Bangalore-krishnagiri- kanyakumari (3745kms)
- NH-48 Delhi- jaipur- Gandhinagar- surat- mumbai - pune- hubli-bangalore- Krishnagiri – vellore- Chennai (2807kms)
- NH-27 Porabandar – Palanpur- Udaipur- agra – Lucknow- silluguri- gauhati- silchar (3507kms)

**State Highway:** State Highways are arterial roads of a state, connecting up with the national highways adjacent state, district head quarters and important cities within the state and serving as the main arteries for traffic to and from district roads.

The NH and SH have the same design speed and geometric design specifications.

**Major District Roads:** MDR are important roads within a district serving areas of production and marketing and connecting those with each other or within the main highways of a district. The MDR has lower speed and geometric design specifications than NH/SH.

**Other District Roads:** ODR are serving rural areas of production and providing them with outlet to market centres, Taluk head quarters, block development head quarters or other main roads. MDR are of lower design specifications than MDR.

**Village Roads:** VR roads connecting villages or group of villages with each other to the nearest road of a higher category.

### 3.2.2 Modified classification of Road system by Lucknow plan:

The roads in the country are now classified into three classes, for the purpose of transport planning, functional identification, earmarking, administrative jurisdiction and assigning priorities on the road network.

1. Primary system
  2. Secondary system
  3. Tertiary system or Rural roads
1. Primary system consists of two categories:
    - Expressways
    - National Highways (NH)

Expressways are a separate class of highways with superior facilities and design standards and are meant as through routes having very high volume of traffic. The expressways are to be provided with divided carriage ways, controlled access, grade separations at cross roads and fencing. These highways should permit only fast moving vehicles.

2. 2 Secondary system consists of two categories:
  - State Highways (SH)
  - Major District Roads (MDR)
3. Tertiary system consists of two categories:
  - Other District Roads (ODR)
  - Village Roads (VR)

### **3.4 Classification of Urban Roads:**

The urban roads are

- Arterial roads
- Sub-arterial roads
- Collector streets
- Local streets

Arterial roads and Sub-arterial roads are streets primarily for through traffic on a continuous route, but the sub-arterials have a lower level of traffic mobility than the arterials.

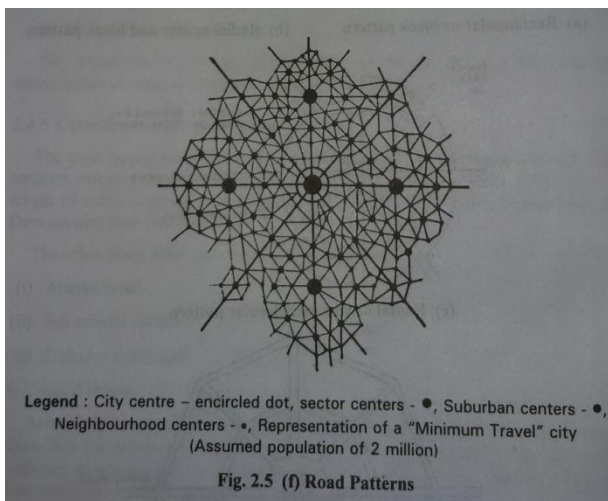
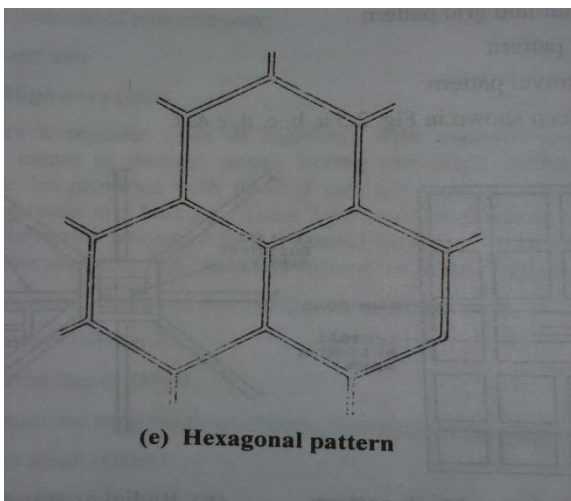
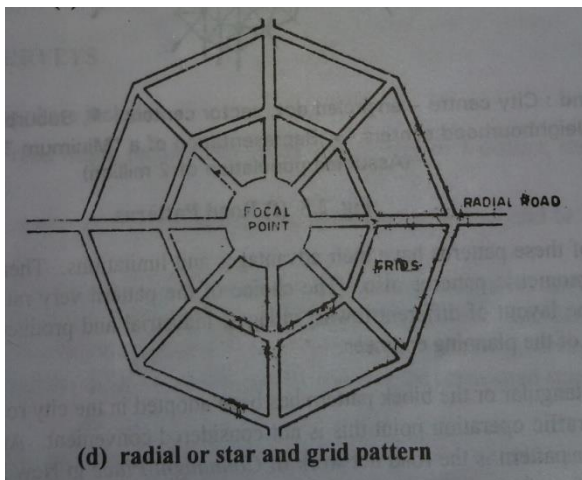
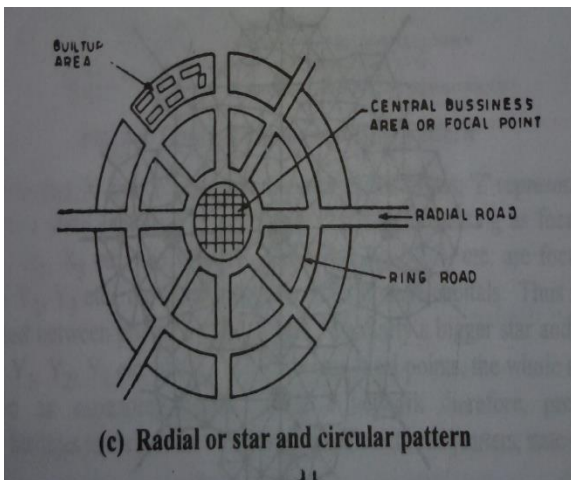
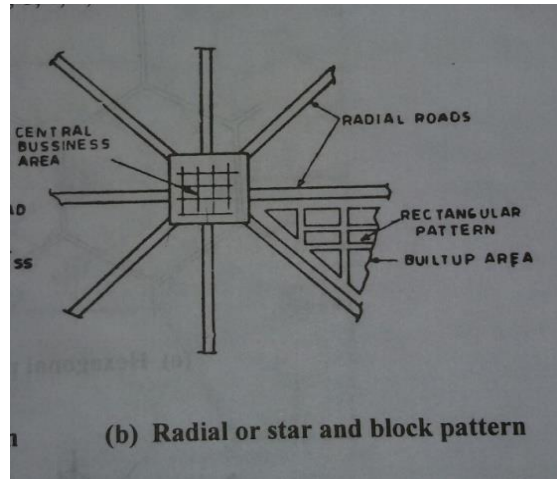
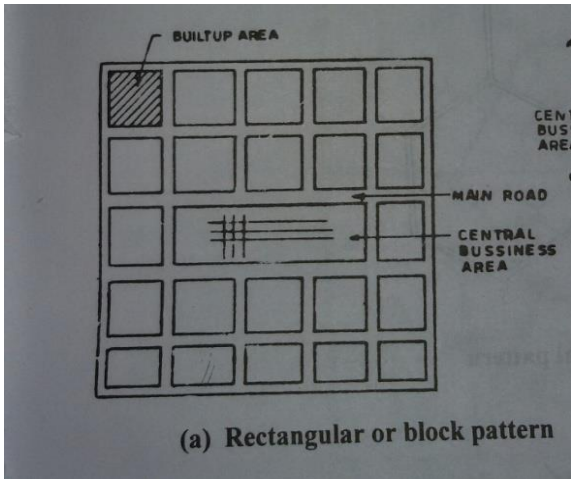
Collector streets provide access to arterial streets and they collect and distribute traffic from and to local streets which provide access to abutting property.

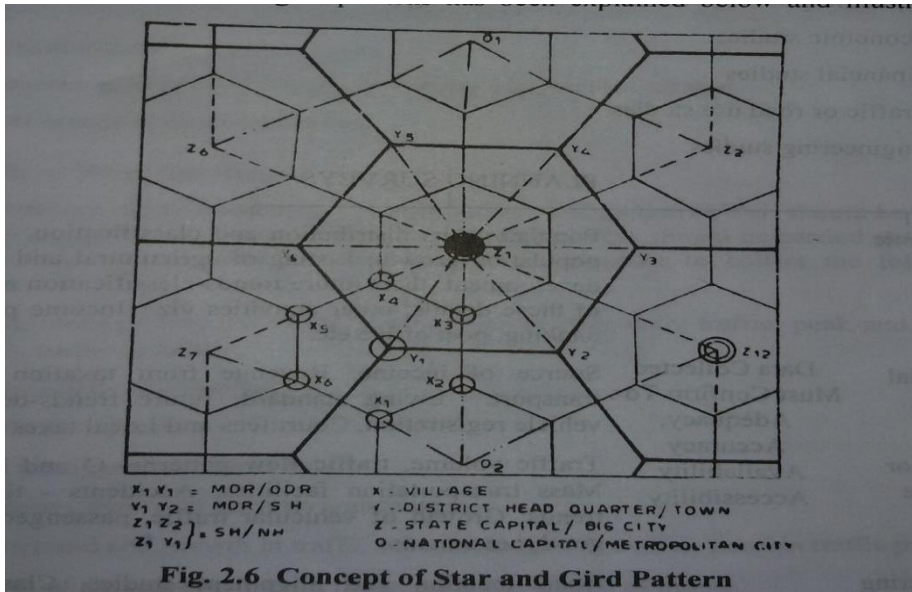
### **3.5 Road patterns:**

The various road patterns may be classified as follows

- 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







#### 4.0 Planning surveys:

Highway planning phase includes,

- Assessment of road length requirement for an area.
- Preparation of master plan showing the phasing of plan in annual and or five year plans.

Field surveys are to be carried out to collect the data required for determining the length of road system. The field surveys thus required for collecting the factual data may be called as planning surveys or fact finding surveys.

The planning surveys consists of the following studies:

- Economic studies
- Financial studies
- Traffic or Road user studies
- Engineering studies

#### Economic studies:

- Population and its distribution in each village, town or other locality with the area classified in groups.
- Trend of population growth.
- Agricultural and industrial products and their listing in classified groups, area wise.
- Agricultural and industrial development and future trends.
- Existing facilities with regard to communication, recreation and education etc.
- Per capita income.



**Financial studies:**

- Sources of income and estimated revenue from taxation on road transport.
- Living standards.
- Resources at local level, toll taxes, vehicle registration and fines.
- Future trends in financial aspects.

**Traffic or Road user studies:**

- Traffic volume in vehicles per day, annual average daily traffic, peak and design hourly traffic volume.
- Origin and Destination studies.
- Traffic flow patterns.
- Mass transportation facilities.
- Accidents, their cost analysis and cause.
- Future trend and growth in traffic volume and goods traffic
- Growth of passenger trips and the trend in the choice of modes.

**Engineering studies:**

- Topographic surveys.
- Soil surveys.
- Location and classification of existing roads.
- Estimation of possible developments in all aspects due to the proposed highway development.
- Traffic studies, Origin and Destination studies.
- Special problems in drainage, construction and maintenance of roads.

**5.0 Interpretation of planning surveys:**

The data collected could be interpreted and used for the following important purposes.

- To arrive at the road net-work, out of the several alternate possible systems, which has the maximum utility.
- To fix up priority of the construction projects, so as to phase the road development plan of an area in different periods of time such as five year plans and annual plans
- To access the actual road use by studying the traffic flow patterns. This data may therefore show areas of congestion which need immediate relief.
- Based on the traffic type and intensity and the performance of existing type of pavement and cross drainage structures, a new structure may be designed using the data and the past experience.

- Comparison of the areas may be obtained on the basis of their economic activities. This information may therefore suggest the areas of immediate need for road network.
- The data obtained in fact finding surveys may be analysed for the future trends in development of an area i.e. Growth in productivity and population which in turn generate higher traffic volume. This information may be useful in the future planning.

### 5.1 Preparation of master plan and its phasing:

Master plan is the final road development plan for the area under study which may be a block, taluk, district, state or the whole country.

Based on the plans, different possible net work of new roads and improvement of some of the existing roads are proposed.

In each proposal the population and productivity (industrial and agricultural) of each locality, the traffic flow, topography and all other details, both existing and possible changes in future are kept in view.

### 5.2 Saturation system:

In this system the optimum road length is calculated for area, based on the concept of obtaining maximum utility per unit length of road. Hence this system is called as saturation system or maximum utility system.

The factors which are taken for obtaining the utility per unit length of road are:

- Population served by the road network
- Productivity served by the network
  - Agricultural products
  - Industrial products

**5.2.1 Population units:** Since the area under consideration may consists of villages and towns with different populations, it is required to group these into some convenient population ranges and to assign some reasonable values of utility units to each range of populations served.

- Population less than 500, utility unit = 0.25
- Population 501 to 1000, utility unit = 0.50
- Population 1001 to 2000, utility unit = 1.00
- Population 2001 to 5000, utility unit = 2.00

**5.2.2 Productivity units:** Total agricultural and industrial products served by each road system should be worked out. The productivity served may be assigned appropriate values of utility units per unit weight. For example one thousand tonnes of agricultural products may be considered to one unit.

**Utility:** The total utility units of each road system is found by adding the population units and productivity units. The total units are divided by the total road length of each system to obtain the utility rate per unit length.