

**Transportation Engineering I – CV53****MODULE 1****IMPORTANCE OF TRANSPORTATION****ROLE OF TRANSPORTATION**

- The **evolution and advancements** in transportation facilities have been closely linked with the development of human being throughout the history of the world .
- Transportation is vital for the **economic development of** any region since every commodity produced, whether it is **agricultural or industrial product needs** to be transported at various stages **from production to distribution**.
- **At the production stage**, transportation is required for carrying raw materials like seeds, manure, coal, steel, machines, component parts, etc.
- **At the distribution stage**, transportation is required from the production centers like the **farms and factories** to the **marketing centers and later to the retailers and to the consumers**.
- **Inadequate transportation facilities** retard the process or socio-economic and cultural development of the country.
- **Development of adequate transportation system in a country indicates** its economic growth and progress in social development.
- **In the present day concept, the main objective** of a good transportation system is to **provide safe, economical, efficient transportation facility** for the travel of passengers and transportation of goods.

**ECONOMIC ACTIVITY AND TRANSPORT**

- Economic activities **are the processes** in which **the products are utilized to satisfy human needs**.
- **Two important factors well known in economic activity** are: (i) Production or supply and ii) Consumption for human wants or demand
- The people, **their products and the natural resources** of the locality **are not bound to the local surroundings**.
- The importance **of transportation in economic activity has its effect** on meeting the demand for goods and also by enhancing **the efficiency of production and distribution**.
- **Increased productivity** of various items such as **agricultural and industrial products and their distribution** through efficient transportation system can **lower the cost of the products**.
- The **cost of transportation substantially influences** the consumer price of the commodities.

## SOCIAL EFFECTS OF TRANSPORTATION

- **Progress follows** the lines of transportation
- **Population have always settled** along the transportation routes such as road side, river shore and near railway stations and sea ports.
- **Developments have also taken place along the routes** where transportation facilities are available, such as the **road sides**.
- However in the **present concept of road network planning**, this kind of ribbon development is very much discouraged, keeping in view the requirements of high speed travel and road safety issues.
- **Attempts are being made to decentralize the population centers** away from the sides of the main transportation routes.
- Thus town **planning patterns are changing**
- **To avoid congestion around the populated areas**, suburban living and industrial enterprises are developing away from the urban centers

The various **social effects** of transportation may be further elaborated as follows:

### (a) SECTIONALISM AND TRANSPORTATION:

- **Improved, transportation has important implication in reducing sectionalism within the country** and also with other countries of the world.
- The living condition and facilities of under-developed **colonies and tribes get improved** since the distances are apparently **reduced with reduction in travel time**.
- More frequent **travels to other parts of the country and outside the country tend to increase knowledge of the people by learning from other sections of the society resulting in improved trade and cultural exchanges**.
- **International understanding for better peace and order also improves** with efficient network of transportation

### (b) CONCENTRATION OF POPULATION IN URBAN AREA:

- **Improved transportation facilities bring prosperity** to the urban population.
- The **employment opportunities, prosperity and superior facilities for education**, medical care etc. **available in urban area attract the population** from other areas, resulting in enhanced economic activities.
- **Adequate mass transportation facilities are needed to cater** for the internal movements in

urban area such as daily movements to and from factories, offices, schools, hospitals and travel for other social needs.

- **Efficient rapid transit facilities are necessary** for sub-urban and inter-city long distance travel for business, social needs and tourist activities.
- **Inadequate transportation facilities lead to concentration** of population in cities which often result in growth of slums in urban areas, leading to various associated problems.
- **If efficient transportation facilities are available**, the people **would prefer to reside at localities away from urban centers**
- In general the transportation **facilities are essential for the well being of the community**

### (c) ASPECT OF SAFETY LAW AND ORDER.

- **Transport facilities are essential for rushing aid to areas affected by an emergency.**
- To **maintain law and order at home**, it is required to have an efficient system of transport network.
- **To defend the territory of the country against** the external aggression and to guard the borders with the foreign territories, **transport facilities are needed**, connecting the farthest border area **from the headquarters or the capitals.**
- At times, **defence needs alone may be a sufficient reason** to develop a transport network which may not provide economic or social benefits directly

The social effects and the resultant advantages of transportation may be summarized as follows:

- (i) **Transportation helps in the progress and advancement of the community**
- (ii) **Efficient transportation is essential** for the **economic prosperity and general** development of the country, and
- (iii) **Transportation is essential for strategic movement in emergency for defence** of the country and to **maintain better law and order**

## DIFFERENT MODES OF TRANSPORTATION

### BASIC MEDIA

- Transportation has **developed along three basic** media a) **land** (b) **water** (c) **air**
- **Land has given scope for development** of transportation by **roads and railways.**
- **Water and air media have developed waterways and airways** respectively.
- **The roads or the highways not only include the modern highway system** but also includes the urban **arterials and city streets**, feeder roads and village roads, catering for a wide range of road **vehicles and the pedestrians**
- **Railways have been developed** both for long distance transportation of goods and passengers

and also for urban travel.

- **Waterways include transportation** by oceans, rivers, canals and lakes, for the movement of ships and boats.
- **The air-ways help in** faster transportation by aircrafts and carriers.
- Thus the following are the four major modes of transportation:

(1) Roadways or highways for road transportation (2) Railways for rail transportation

(3) Waterways for water transportation(4) Airways for air transportation

## ROAD TRANSPORTATION

- Transportation by road system is the only **mode which could give maximum flexibility** of service from origin to destination, to one and all.
- **Various classes of vehicles such** as car, bus, truck, two- wheeler, etc. may be permitted to make use of the roads.
- **Apart from the road vehicles, pedestrians also** make use of the facilities of the road system.
- Road transport made has **the maximum flexibility** for travel with reference to choice of the route, direction, time and speed of travel.
- Road transportation is the **only mode which caters for the movement of passengers and goods independently** right from the place of origin up to the destination of any trip along the land
- In other words, **it is possible to provide door to door service** only by road transport
- **The other three modes, viz., railways, waterways and airways have to depend on transportation** by road for the service to and from their respective terminals viz, railway stations, harbours and airports.
- Therefore road network is **essential to serve as feeder system for all other modes** of transportation and also to supplement them
- Thus it is **necessary to develop a well planned road network throughout** the country so as to serve both as an independent transport system and also as feeder transport for the other three modes of transport.
- ❖ **The limitations of road transport** are that the rate of petroleum energy consumed (for transportation of unit weight by unit distance) is higher than for transportation by railways and waterways.
- ❖ The **rate of emission of pollutants** is also **higher than the other modes of transport**.
- The branch of **transportation engineering that deals with** the planning, design, construction and maintenance of roadway facilities is termed Road Engineering or Highway

Engineering.

- ❖ From the point of **view of conservation of energy in the country and minimizing the air pollution** due to transportation, **it is desirable to work out and implement a national policy on co-ordination** between various modes of transportation
- ❖ **However implementation of such a policy will not be easy in a democratic country like India.**
- ❖ Therefore it may be **necessary to permit a healthy competition** between the **different modes of transportation.**

## RAIL TRANSPORTATION

- **The concept of rail transportation is movement of multiple wagons or a train of wagons or passenger bogies fitted** with steel wheels running over two parallel steel rails of the railway track.
- The **resistance to traction along the railway track** for the movement of the steel wheels of the rail wagons **is much lower than that along the more uneven road surface** for the movement of road vehicles with rubber tires, under identical conditions of speed and atmospheric factors.
- **The energy requirement to haul unit load through unit distance by the railway is only a fraction (one fourth to one sixth) of that required by road.**
- Therefore **full advantage of rail transportation should be taken for the transportation or bulk goods and passengers, especially for long distance on land routes** and where the railway tracks are available.
- ❖ **Rail transportation between the railway stations could be economical and advantageous both for the passengers and also for transportation of goods on long haul distances.**
- ❖ The **railways can transport a large number** of passengers or a large quantity of goods at a time
- ❖ The **railways also serve as mass rapid transport** for the people to travel from the suburban areas to the urban centers and for travel within the urban area of large cities,
- ❖ Different **types of locomotives with steam or diesel engines of electric locomotives** along the electrified railway tracks have been used in India to haul the trains
- ❖ however **steam locomotives utilizing heat energy produced by burning coal** has got almost extinct in our country due to poor energy efficiency and pollution.
- ❖ The branch of transportation engineering which deals with the planning, design. construction and maintenance of the railway track, rail stations and the yards including the control system and safety devices is **called Railway Engineering**
- The transportation **to and from the railway stations are to be performed** by road transportation.
- The **railway tracks could serve** as arteries for transportation of passengers and goods on land **routes at relatively low cost** and the **roads could serve as feeder system** for

transportation to the interior parts and to the intermediate localities between the railway stations

- Therefore **in order to conserve energy, an integrated rail-cum-road transport net work** could be advantageous in a developing country like India
- Indian Railways has one of the **World's largest Railway** network in the world.
- Indian railways were introduced in **1853**.
- Indian Railway net work **is spread over** 109,221 km, covering 6906 stations.
- Operating on **three gauges - broad gauge** (1676mm), **meter gauge** (1000 mm) and **narrow gauge** (762 and 610 mm), trains in India carry about 17.7 million passengers and 1.49 million tones of freight every day.

## WATER TRANSPORTATION

- **Transportation by train offers minimum resistance** to traction and therefore needs minimum energy to haul unit load through unit distance.
- The **amount of energy required to propel a vessel on water is much lesser** than that required on land and is far lesser than that required to keep an aircraft air-borne.
- Therefore water transportation **is the most energy efficient**.
- But, water transportation **is very slow**, which is the greatest **disadvantage of this mode**.
- In fact, **this is the slowest among** the four modes.
- Though **some passenger traffic makes use of water transportation**, the greatest user of this mode is bulk cargo of relatively low value, mainly because of the slow speed and low transportation cost for the bulk cargo
- ❖ Waterway is **needed to operate the ships and boats on sea** routes between the harbours and ports.
- ❖ Harbours **are terminals built with components** such as docks, quays, wharfs, etc.
- ❖ The **other facilities required are to provide shelter to the ships** and the crews and also facilities for loading, unloading and storage of cargo and for carrying out routine and major maintenance of the vessels.
- ❖ The branch of transportation engineering which deals with the plan, design, construction and maintenance of docks and harbours is called **Harbour Engineering**.
- **Inland water transportation is made possible along** the rives, canals and lakes by boat and ferry service, which operate between small ports
- Inland waterways, being of relatively **shallow depth, the freight is mostly** carried on **barrages and are hauled by towing boats**.

- The road and rail transport serve as feeder system to transfer goods and passengers to and from the harbours and ports.

## AIR TRANSPORTATION

- Transportation by air is the fastest among the four modes.
- An transport provides more comfortable and fast travel resulting in substantial saving in travel time for the passengers between the airports.
- The shipment of high-value freight on long hauls is possible in the shortest time by air transport.
- Unlike other modes of transport, air transport allows continuous journey over the land and water, even across inaccessible places in between two airports.
- One of the limitations is that the energy required and the overall operating expenses for air transportation are the highest in comparison to the other modes.
- Another limitation is that operation of air transport is very much affected by weather conditions such as severe storms and thick fog.
- Airports are developed to provide facilities for the aircraft for take-off, landing, parking and carrying out maintenance works.
- Some of the essential components of an airport are runway, taxiway, terminal facilities, visual aid, control and safety system.
- The branch of transportation engineering which deals with the planning, design, construction and maintenance of the airports to cater for the needs of the aircrafts that are expected to make use of these airports is called **Airport Engineering**.
- For shorter hauls, helicopters are used and heliports are developed for their landing and take-off
- Military aviation is also important to meet the defense needs of a country.
- The requirements of military airports could vary depending upon several other factors
- ❖ Thus air transportation caters for the movement of passengers and freight between the airports.
- ❖ The travel to and from the airports are to be performed by other modes of transportation, particularly by road transportation or by both rail and road transportation

## CHARACTERISTICS OF ROAD TRANSPORT

- It is an accepted fact that of all the modes the transportation, road transport is the nearest to the people.
- All classes of road vehicles consisting of both personal or public transport vehicles and also the pedestrians can make use of the roadway system.

- **The passengers and the goods can be transported by any suitable type of road vehicle** either for the **full trip from the place of origin to the destination** or to and from the **terminal of other modes** of such as the **railway station, airport or the harbour**.
- **The far border areas located** in high altitudes and difficult terrain of the country and the remote villages in the under developed villages **could be served by the road network**
- **Road transport is considered very convenient and even economical for short trip lengths**
- **Often road transport is preferred even for longer trip lengths** at a higher transportation cost, to avoid the inconvenience of shifting from one mode to another.
- **High-value products are being transported** by road these days, even on **fairly long haul lengths**.
- **Because of the flexibility road transport has received the widest acceptability.**

#### **THE CHARACTERISTICS OF ROAD TRANSPORT ARE BRIEFLY LISTED HERE**

- Roads are used by various types of road vehicles**, like passenger cars, buses, trucks, two and three wheeled automobiles, pedal cycles and animal drawn vehicles and also the pedestrians. But **the rail locomotives and wagons can only make use of the railway tracks**. The **ships and boats can make use of only the waterways and the aircraft's, only the airports**
- Road transport infrastructure requires the lowest initial investment in comparison to** that for the infrastructure of other transportation modes cost of any class of road vehicle is much lower than that of other carriers like the **railways** (consisting of the rad locomotives and wagons), **ships and aircrafts**. **The initial cost of construction and the cost for maintenance of roads is also lesser** than those for railway tracks, harbours and airports
- Roads offer complete freedom to the road users to make use of the roadway facilities at any time** convenient to them or to move the vehicle from a lane of the road to the adjoining one and from one road to another, according to the need and convenience. **The flexibility of changes in location, direction, speed and timings of travel is not available** to other modes of transport
- It is possible to travel directly from the respective places of origin to the destination** by road vehicles. **For short distances in particular, road transport saves time** and is most convenient
- Speed of movement is directly related with the severity of accident.**

**The road safety decreases with increasing running speed** and the speed dispersion in the traffic streams. Road transport is **prone to a high rate of accidents due to the flexibility** of movements offered to the road users, with a wide range of travel speeds along the same roadway. However in other modes of transport, in spite of **various safety measures and strict controls in the movements major accidents** do occur even in the form of **head-on collisions and the accidents in these modes are more severe and disastrous**

- Road transport is the only mode **that offers the facilities to the whole section of society**

#### **JAYAKAR COMMITTEE RECOMMENDATIONS**

- JAYAKAR Committee submitted its report by the year 1928.



- The most **Optimum recommendations made** by the committee are as follows
  - (a) **The road development in the country should be considered as a national interest** as this has become beyond the capacity of provincial governments and local bodies
  - (b) **An extra tax should be levied on petrol from the road users to develop a road development fund called 'Central Road Fund'**
  - (c) **A semi - official 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
  - (d) **A research organization should be instituted** to carry out research and development work pertaining to roads and to be available for consultations
- ❖ Most of the recommendations of JAYAKAR Committee **were accepted by the government, and the major recommendations were implemented subsequently.**
- ❖ The Central Road Fund was formed by the year 1929, the semiofficial technical body called the 'Indian Roads Congress' was formed in 1934 and the Central Road Research Institute was started in the year 1950.

#### **OBJECTIVES OF CENTRAL ROAD FUND**

- **Based on the authority of a resolution adopted by the Indian Legislature** the Central Road Fund was formed on 1st March 1929.
- **At that period the consumers of petrol were charged an extra** levy of 2.64 paisa per liter (then two Annas per gallon) of petrol to build up this road development fund.
- **20 percent of the annual revenue is to be retained as a Central Reserve**, from which grants are to be given by the Central Government for 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 is to be allotted by the Central Government to various states** based on actual petrol consumption or the levy collected on sale of petrol.
- **The accounts of the Central Road Fund are maintained by the Accountant General** of Central Revenues and the control on the expenditure is exercised by the Roads Wing of Ministry of transport
- Subsequently the **rate of collection of the levy towards the CRF has been revised** in order to the revenue under this fund and also due to the increase in cost of petroleum.
- ❖ **Central Road Fund Act - 2000 was notified in December 2000 which gave statutory status** to the existing Central Road Fund governed by resolution of the Parliament in 1988
- ❖ The **rate of duty on petrol and high speed diesel (HSD) was then fixed** as one Rupee per liter.

- ❖ **At present the revised cess collected on petrol and HSD towards CRF is @ Rs 2 per liter.**
- ❖ **The fund accrued is distributed for the development and maintenance of national highways, state roads and rural roads and for constructing identified grade separators across railway tracks.**

### INDIAN ROADS CONGRESS

- ❖ At the instance of central government a **semi-official technical body known** as Indian Roads Congress was formed in **1914**.
- ❖ It may be recalled that this was one of the **main recommendations made by the Jayakar Committee**.
- ❖ The Indian Roads Congress was **constituted to provide a forum for regular** pooling of experience, technical knowledge and ideas on all matters related to the **planning, construction and maintenance of roads in India**.
- ❖ **The IRC will prepare standard specifications and provide a platform for the expression** of professional opinion on matters relating to road engineering including those of organization and administration.
- Now the **Indian Roads Congress has become an active body of national** impendence controlling specifications standards and guidelines on materials, design and construction of roads and bridges.
- **The IRC publishes journals, research publications**, standards specifications, guidelines and other special publications on various aspects of highway Engineering.
- **The technical activities of the IRC are mainly carried out** by the Highway research Board and several committees and sub committees consisting of experts in each subject.
- The IRC works in close collaboration with Roads Wing of the Ministry of Road Transport & Highways Government of India.

### OBJECTIVES OF IRC

- ❖ To **promote and encourage** the science and practice of building and maintenance of roads;
- ❖ To **provide a channel for** the expression of collective opinion of its members regarding roads;
- ❖ To **promote the use of standard specifications and to propose** specifications;
- ❖ To **advise regarding education, experiment and research connected with roads**;
- ❖ To **hold periodical meetings**, to discuss technical questions regarding roads;
- ❖ To **suggest legislation** for the development, improvement and protection of roads;
- ❖ To **suggest improved methods of administration**, planning design, construction, operation,

use and maintenance of roads;

- ❖ **To establish, furnish and maintain libraries and museums** for furthering the science of road making;
- ❖ **To publish, or arrange for the publication of proceedings**, journals, periodicals and other literature for the promotion of the objects of the Society;
- ❖ **To accept subscriptions, subsidies, donations, and gifts in furtherance** of the objects of the Society;
- ❖ **To invest and deal with the funds of the Society or entrusted to the Society, to acquire and hold any movable or immovable property**, and to borrow or raise money for the furtherance of the objects of the Society and to sell, lease, exchange, or otherwise deal with the same;
- ❖ **To grant pay, prizes, scholarships (including traveling scholarships)** for meritorious work in furtherance of the objects of the Society;
- ❖ To do all such other lawful and the attainment of the above objects;

#### **CENTRAL ROAD RESEARCH INSTITUTE**

- **In the year 1950**, the Central Road Research Institute (CRRI) **was started at New Delhi** for carrying out research pertaining to road technology.
- It may be indicated that **one of the recommendations of Jayakar Committee report** was to set up a **central organization for research and dissemination** of information.
- The CRRI is **one of the national laboratories** of the Council of Scientific and Industrial Research (CSIR).
- **The institute is mainly engaged in carrying out applied research in various aspects of highway engineering and offers technical advice to state governments** and the industries on various problems concerning roads.

#### **THE SCIENTIFIC & TECHNICAL OBJECTIVES OF CRRI ARE :**

- **To develop specifications and manuals for construction of low cost roads** for different regions of the country.
- **To carry out applied research for investigation, construction and maintenance of different types of roads** and runway including studies on related materials such as aggregates, bitumen, cement, etc. with a view to **effecting economy and achieving greater serviceability**.
- **To develop appropriate tools, machinery, equipment and instruments for adapting technologies** as related to highway engineering and relevant to the country for indigenous use.
- **To carry out research and development activities** in all aspects of roads **under varying**

climatic and traffic conditions.

- **To carry out research and development in all aspects of road traffic and transportation engineering, including study of accidents, development of road safety measure, psychology of road users and transportation economics in relation to different forms of transport.**
- **To render technical advice and consultancy services to various organisation in roads and related fields to avoid import of foreign expertise.**
- **To train engineers through refresher courses, workshops and training programmes for wider application of developed technologies.**
- **To create and establish all the needed infrastructure, both equipment and expertise, in the various facets of highway and transportation engineering for investigation, planning, design, construction and maintenance as well as to achieve judicious solutions for special problems.**
- **To collaborate with other institutions for R & D studies concerning roads, road transportation and related practices particularly on regional problems.**
- **Publication of scientific and technical findings in journals, conferences, etc. related to research and development in related areas of highway engineering.**

### **HIGHWAY RESEARCH BOARD**

- The Highway Research Board of the **Indian Roads Congress was set up in 1973** with a view to give proper direction and guidance to road research activities in India.
- The board is **expected to act as a national body for co-ordination** and promotion of highway research
- The Highway Research Board (HRB) has recommended **suitable financial allocation of research by central and state governments** and has **chosen high priority research schemes for being taken up first.**

### **The objectives of IRC Highway Research Board are to:**

- **To ascertain the nature and extent** of research required.
- **To correlate research information from various organizations** in India and **abroad with a view** to exchanging publications and information on roads.
- **To co-ordinate and conduct** correlation services.
- **To sponsor basic research through** universities and research organizations.
- **To collect and disseminate** results of research.

- **Any other matter related** to road research.
- **Channelize consultative** services

### **THE OBJECTS OF HIGHWAY PLANNING**

**(a) To plan overall road net work for efficient and safe traffic operation, but at minimum cost.**

Here the costs of construction, maintenance and resurfacing or strengthening of pavement layers and the vehicle operation cost are to be given due consideration

**(b) To arrive at the road system and the lengths of different categories of roads** which could **provide maximum utility and could be constructed within the available resources** during the plan period under consideration

**(c) To divide the overall plan into phases and to decide priorities**

**(d) 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

**(e) To plan for future requirements and improvements** of roads in view **of anticipated developments**

**(f) To work out suitable financing system**

**PHASES OF HIGHWAY PLANNING** Highway planning includes the following phases

**(a) Assessment of road length requirement for an area** (it may be a district, state or the whole country)

**(b) Preparation of master plan** showing the **phasing of plan in five year plans or annual plans**

In order **to plan the road system in the selected region**, state or country, **different studies and surveys are to be carried out** to collect the data required.

**The data collected are to be processed and analyzed to arrive at the best possible** road network and to arrive at the optimum length of the road system

### **CLASSIFICATION OF ROADS**

#### **DIFFERENT APPROACHES**

##### **Types of roads**

The roads are generally classified into two categories, depending on whether they can be used during **different seasons of the year**

**(i) All-weather roads and (ii) Fair-weather roads**

- **All-weather roads** are those which are negotiable during all seasons of the year, **except at major river crossings where some interruption to traffic** is permissible up to a certain extent, but the road **pavement should be negotiable during all weathers.**

- On 'fair weather roads' the traffic may be interrupted during monsoon season at causeways where streams may overflow across the road.

#### **Based on the type of the carriageway or the road pavement**

- The roads are classified as 'paved roads' and 'un-paved roads'.
- The roads with a hard pavement surface on the carriageway are called 'paved roads'.
- The roads without a hard pavement surface on the carriageway are called 'unpaved roads'.
- Earth roads and gravel roads may be called **unpaved roads**.

#### **Based on the type of pavement surfacing provided**

- The roads may be classified as 'surfaced roads' and 'un-surfaced roads'.
- Road pavements **with any type of bituminous surface or cement concrete** are called **surfaced roads**.
- The roads which **are not provided with a bituminous or cement concrete** surfacing are called **un-surfaced roads**.

#### **Methods of classification of roads**

The roads are generally classified based on the following:

- Traffic volume**
- Load transported or tonnage**
- Location and function**

- The roads are classified as heavy, medium and low volume roads.
- These terms are relative and so the limits under each class should be clearly defined and expressed 'annual average daily traffic', etc.

#### **The classification based on load or tonnage**

the roads may be classified as class I, II etc. or class A, B etc. and the limits may be expressed in **terms of tones per day**.

#### **Road classification based on location and function**

##### **Road classified as per Nagpur road plan**

- (i) National highways (ii) State Highways
- (iii) Major District Roads (MDR)
- (iv) Other District Roads (ODR) and
- (v) Village Roads (VA)

- **National Highways (NH) are main highways running** through the length and breadth of India, **connecting major ports, foreign highways, capitals of large states and large industrial and tourist centers** including roads required for strategic movements and the defense of India.

- It was specified that national highways should be the frame on which the entire **road communication should be based and that these highways may not necessarily be of same specification**.

- **but they must give an uninterrupted road communication** throughout the country and **should connect the entire road network**.

- The **responsibility of construction and maintenance** of national highways was decided to be with the central government.

- All the **national highways are assigned** the respective **numbers**. For example,

NH-1 is the national highway connecting Delhi, Ambala, Jalandhar and Amritsar (up to Pakistan border);

NH-4 connects Thane, Pune, Belgaum, Hubli, Bangalore, Chittoor and Chennai

- **State Highways (SH) are arterial roads of a state, connecting the national highways of adjacent state, district head quarters and important cities within the state and serve as the main arteries for traffic to and from district roads**. • These highways are considered as **main arteries of commerce by road within state** or a similar geographical unit.

- **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 markets and connecting with other major roads or main highways of a district the MDR has lower speed and geometric design specifications** than NH/SH.

➤ **Other District Roads (ODR) are roads serving rural areas of production and providing them with outlet to market centers, taluk head quarters, block development head quarters or other main roads.**

➤ These are of **lower design specifications than MDR**.

- **Village Roads (VR) are roads connecting villages or groups of villages with each other to the nearest road of a higher category.**

### **Modified road classification third 20-year road development plan, 1981 - 2001**

- The roads in the country are now **classified into three classes**, for the **purposes of**

**transport planning, functional identification, administrative jurisdictions and assigning priorities on a road network.**

- (i) **Primary system**
- (ii) **Secondary system and (iii) Tertiary system or rural roads**

Primary system consists of **two categories of highways**:

(a) **Expressways and**

(b) **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 value of traffic**.
- The expressways are to be **provided with** divided **carriageways, controlled access, grade separations at cross roads and fencing**.
- These highways **should permit only fast moving vehicles**.
- Expressways may be **owned by the Central Government Of State Government**, depending on whether the route is it National highway or State Highway.
- The National Highways **form the other main category of primary system** in the country.

The Secondary system consists of **two categories of roads**:

- (a) **State Highways (SH) and**
- (b) **Major District Roads (MDR)**

The Tertiary systems are rural roads and these consist of **two categories of roads**:

- (a) **Other District Road (ODR)**
- (b) **Village Roads (VR)**

### **Classification of urban roads**

- The road systems within urban areas are classified as Urban Roads and will form a separate category of roads to be taken care by the respective urban authorities.
- The lengths of urban roads are not included in the targets of the Third Twenty Year Road Development Plan 1981-2001.

The **urban roads are classified as**

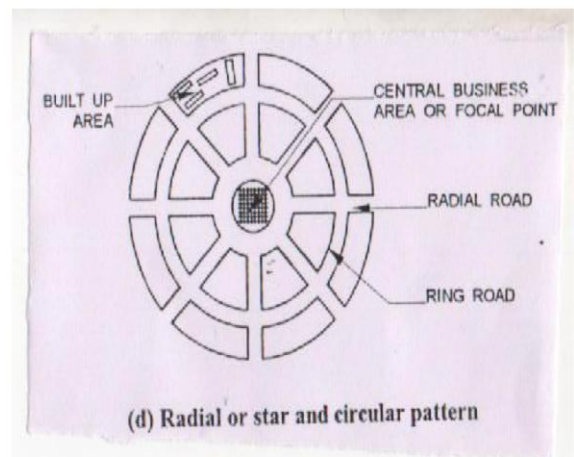
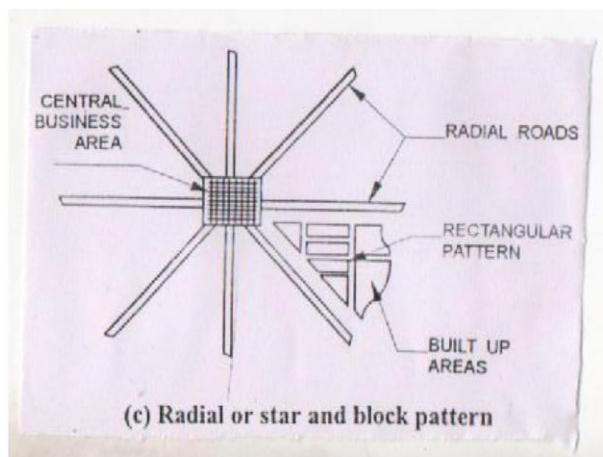
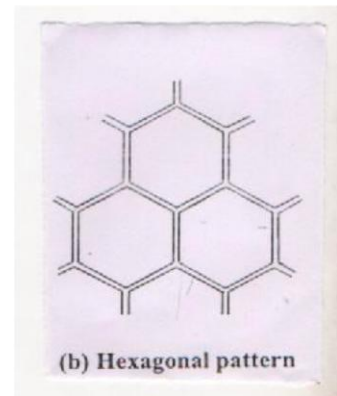
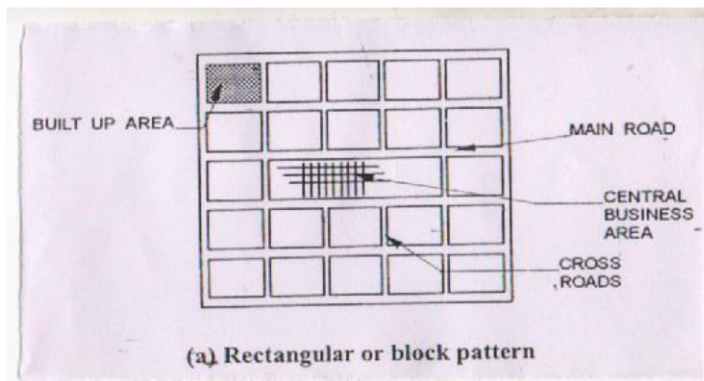
- (a) **Arterial roads**
- (b) **Sub-arterial roads**



- (c) **Collector streets and**
- (d) **Local streets**

## **ROAD PATTERNS**

- (a) **Rectangular or block pattern**
- (b) **Hexagonal pattern**
- (c) **Radial or star pattern and block pattern**
- (d) **Radial or star and circular pattern**
- (e) **Radial or star and grid pattern**
- Each of **other geometric patterns** has its own **advantages and limitations**
- There can be **number of other geometric patterns** also
- The **choice of pattern** very much depends on the **locality, the lay out of different** towns, villages, industrial and production centers and on the choice of planning engineer.
  - The **rectangular or the block pattern** has been adopted in the city roads of Chandigarh.
  - But from the **traffic operation point** this is not considered convenient
  - **An example of radial and circular pattern** is the road network of Connaught place in new Delhi



The Nagpur road plan formulae were prepared assuming 'Star and Grid pattern'. The concept of star and grid patterns are illustrated in Fig. 2.3 and have been explained below.

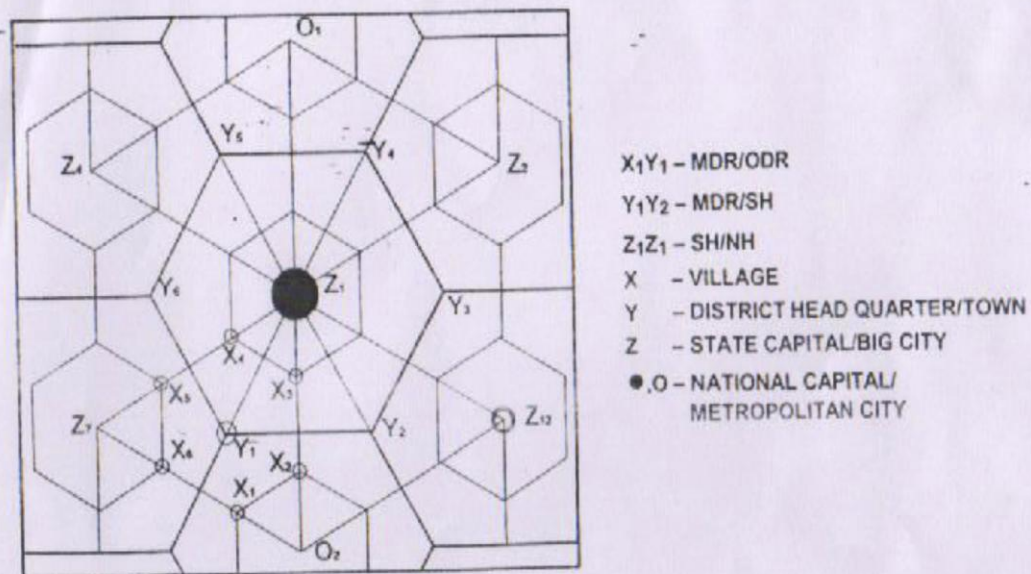


Fig. 2.3 Concept of star and grid pattern

- In Fig. 2.3 points X are assumed to be villages, points Y the towns and points Z represent the district head quarters or state capitals.
- Points Y1, Y2, Y3, etc. act as focal points for connecting the villages X1, X2, X3, etc.
- Similarly Z1, Z2, Z3, etc. are focal points for connecting the towns Y1, Y2, Y3 etc.
- Thus star and grid pattern is formed between X1, X2, X3, etc.
- Similarly bigger star and grid pattern are formed with Y1, Y2, Y3 etc. and Z1, Z2, Z3, etc. as focal points.
- Thus the whole area can thus be covered on an expanding scale.
- Such a network therefore, provides Inter-communication facilities to each of the villages, towns, district headquarters, state capitals etc.

## PLANNING SURVEYS

- The studies for collecting the factual data for highway planning are known as 'fact finding studies' or 'planning surveys'.
- The fact - finding studies point to an intelligent approach for planning and these studies should be carried out if the highway programme is to be protected from inconsistent and short sighted policies.

- **Planning based on the factual data and analysis** may be considered scientific and sound.

The planning surveys consist of the following studies:

- (a) **Economic studies**
- (b) **Financial studies**
- (c) **Traffic or road use studies**
- (d) **Engineering studies**

### **ECONOMIC STUDIES**

- The details to be collected **during economic studies are useful in estimating the requirements, cost involved for the proposed highway improvement programme and the economic justification.**
- Hence it is **desirable to find the service given by each road system to the population and various types of products** (such as different types of agricultural produce and industrial products) of the area.
- It is **essential to first collect all details of the existing facilities, the deficiencies, future trends additional requirements and the estimated cost** of improvements
- These particulars **are useful to work out economic justification** of each plan.

The **details to be collected include** the following:

- (a) **Total population and classifies' distribution of the different population groups based on occupation, income, etc. in each village, town or other locality and the area of** settlement of each classified in group
- (b) Trend of **population growth** of various population groups .
- (c) **Agricultural and industrial products and their listing** in classified groups, area wise
- (d) **Industrial and agricultural development, diversifications** if any and future trends
- (e) **Existing facilities with regard to** communication, education, banks, hospitals, post office, recreation facilities, etc.
- (f) **Per capita income**

### **FINANCIAL STUDIES**

- The **financial studies are essential to study the various financial aspects such as sources of income.**
- **various types of revenues from duties and taxes on products, road transport. vehicle registration, court fees, etc. and the future trends**

- Also it is necessary to assess the manner in which funds for the project may be mobilized

The details to be collected during financial studies are

- Sources of income and estimated revenue from different types of taxation including revenue from road transport sector
- Standard of living of different population groups and the trend in changes
- Resources at local level, toll taxes, vehicle registration and fines
- Anticipated developments in the area and generated income
- Future trends in financial aspects

### **TRAFFIC OR ROAD USE STUDIES**

- All the details of the existing traffic, such as classified traffic volume, growth rate of different vehicle classes, pattern of flow or origin-destination characteristics, particulars of passenger trips and goods movement, existing facilities for mass transportation trend in road accidents, accident cost. etc. should be collected before any improvement is planned.
- Traffic surveys should be carried out in the whole area and on selected routes and locations in order to collect the following particulars:
  - Classified traffic volume in vehicles per day, annual average daily traffic, peak and design hourly traffic volumes
  - Origin and destination studies based on detailed home interview method
  - Traffic flow patterns
  - Mass transportation facilities
  - Accidents, their causes and cost analysis
  - Future trend and growth in traffic volume and goods traffic; trend in traffic pattern
  - Growth of passenger trips and the trend in the choice of modes

### **ENGINEERING STUDIES**

- All details of the topography, soil and drainage characteristics, alignment of the existing roads, deficiencies in drainage characteristics, deficiencies in alignment and geometries of existing roads, requirements of essential up-gradation, identification of maintenance problems. etc. should be investigated before a scientific plan or programme is suggested.

The required engineering studies include the following:

- **Topographic surveys**
- **Soil surveys**
- **Location and classification** of existing roads
- **Assessment of various other developments in the area** that are likely due to the proposed highway development.
- **Road life studies**
- **Special problems in drainage, construction and maintenance of roads**

## PREPARATION OF PLANS

- The details collected during the planning surveys are tabulated and plotted on the maps of the area under planning.
- Before finalizing the alignment and other details of the road development programme, the information collected during the **fact finding studies are presented in the form of plans.**
- Usually the following **four typical drawings are prepared showing the various details** of the area.

### (I) Plan I:

General area plan showing most of the **existing details**, viz., (a) **topographical details on a contour plan** showing rivers, canals, small streams, valleys, etc. (b) **existing road network and cross drainage structures** (c) **towns and villages with the population** (d) **agricultural, commercial and industrial activities**

### (2) Plan - II:

- Plan showing the **distribution of population groups in accordance** with the categories made in the appropriate plan

### (3) Plan III.

- Plan showing the **locations of places with their respective quantities** of productivity

### (4) Plan - IV:

- Plan showing **existing road network with traffic flows** and 'desire lines' obtained from the **traffic volume and origin - destination studies.**
- **Proposals received from different sources may also be shown in this plan**

## INTERPRETATION OF RESULTS OF PLANNING SURVEYS

- The various **details collected from the planning surveys and presented in the form of plans** should be **interpreted in a scientific way before arriving at the final road development programme.**

- The data collected could be interpreted and used for the following important purposes:
  - (a) **To arrive at the optimum road net-work which has the maximum utility**, out of the several alternate possible systems considered.
  - (b) **To fix up priority of the construction projects**, so as to phase the road development plan of to area in different periods of time such as **five year plans and annual plans**
  - (c) **To assess the actual road use by studying the traffic flow patterns**.

This data may therefore **show areas of congestion which need immediate relief**.

- (d) New structures may be designed using the data and the past experience based on the **traffic type and intensity and the performance of existing types of pavement and cross drainage structures**,
- (e) 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**
- (f) By appropriate statistical analysis, the data obtained during fact finding surveys may be analyzed to predict the future trends in development of an area.

**The growth in productivity and population may be projected** which in turn generate additional bulk volume. **'this information may be useful in the future planning**

## PREPARATION OF MASTER PLAN

### **TARGET ROAD LENGTHS**

- **Master plan is the final road development plan for the study area** which may be a block, taluk (mandal), district, state or the whole country
- Based on the above plans, **different possible network of new roads and improvement of some or 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.
- If some target of road length has been fixed for the country on the basis of area or population and productivity or any other set of criteria, the same may be taken as a guide for deciding the total length of the road system while considering different proposals.
- In developing countries like India, the total target road length to be achieved for the country as a whole, during a selected plan period may be fixed depending upon the **finances that could be made available during the plan period.**
- In India the target road lengths were fixed during the first three 20-year road development plan periods.
- The factors such as population and productivity of each region have also been taken into consideration in addition to **the area to arrive at the length of & different categories** of roads in the respective region under consideration.

### **DETERMINATION OF OPTIMUM ROAD LENGTH**

- The next step is to compare the various alternate proposals of road systems in hand and to **select the one which may be considered as best** under the plan period
- This is a quite difficult problem as the decision has to be a balanced one.
- In arriving at the best road system out of the alternate proposals, it is **desirable to make use of the concept of 'saturation system'** based on U.S. system of highway planning.

### **SATURATION SYSTEM (MAXIMUM UTILITY SYSTEM)**

- In this system the optimum road length is calculated for a area, **based on the concept of obtaining maximum utility per unit length of road.**
- The factors which are taken for obtaining the utility per unit length of road are:
  - (a) Population served by the road network
  - (b) Productivity served by the net work - the productivity served may further be subdivided as
    - (i) agricultural products and (ii) industrial products

The following steps may be followed to find the road net work **having maximum utility per unit** length by the saturation system.

#### **Step (i) population units**

- Since the area under consideration may consist of villages and towns with different populations, it is required to group these into some convenient-population range and to assign some reasonable values of utility units to each range of populations served.
- For example, the road link connecting villages having **population range between 1001 and 2000 may be grouped together and be assigned one utility unit per village.**
- Similarly the various villages and settlements may be grouped in different population ranges and be assigned suitable utility units as indicated in a typical example given below

Population less than 500, utility unit = 0.25

501 to 1000, utility unit = 0.50

1001 to 2000, utility unit = 1.00

2001 to 5000, utility unit = 2.00

- From plan II of population prepared, the number of towns and villages with population ranges served by each road system is found and then converted into the utility units served by each road.
- Thus the total number of units based on population can be obtained for each road system proposed.
- The 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 tone's of agricultural products may be considered equivalent to one unit.
- Similarly the industrial products may also be assigned some suitable utility units per unit weight
- However, coal, raw materials like ores etc. may be assigned lower utility values than the industrial products.
- From plan III showing the products in the area ( the total productivity units served by each road system may be estimated).

Step (iii), utility per unit length of road

- The total utility units served by each road system are found by adding the population units and productivity units.
- The total units scored are divided by the total road length of each system to obtain the utility rate per unit length of road.
- Different road systems considered with different layout and length would show different values of utility rate per unit length.
- The proposal which gives maximum utility per unit length may be chosen as the final road system with optimum road length, based on maximum utility by this method.
- The only limitation of the system is the possible variation in the relative weightages assigned to population and different types of productivity.
- It is possible to give a relatively higher weightage either to the population or to certain types of products.
- A sound judgment based on professional skill and experience should be helpful in providing balanced weightages for arriving at the optimum road length or the best road system with maximum utility per unit length of road

## PHASING OF ROAD PROGRAMME

- After deciding the optimum road length for a plan period the final step is the phasing of the road development plan by fixing up the priorities for the construction of different road links.
- The road network to be constructed and improved in the plan period is decided while finalizing the master plan of the road development project.
- The plan period may be of long term, like that of the 20-year road development plan or of short period like five year plans.
- But whatever be the plan period, it is necessary to phase the road development programme from financial considerations or the expected flow of funds.
- In other words, it is necessary to fix up the priorities for the construction of each road link out of the entire road net work development programme so as to decide which link should be taken up first and which one next and so on.

- The phasing may also be done for each annual budget year by fixing up the priorities
- Here again the priority for each road link may be decided scientifically based on maximum utility criteria, population and productivity served by the respective road

#### SALIENT FEATURES OF THE SECOND 20-YEAR PLAN (1961-81)

- This plan was prepared more scientifically keeping in view a balanced development of developed, semi-developed and undeveloped areas
- The maximum distance of any place in a developed or agricultural area would be 6.4 km from a surfaced road and 2.4 km from any category of roads.
- The maximum distance from any place in a semi developed area would be 12.8 km from a surfaced road and 4.8 km from any road;
- Similarly The maximum distance in an undeveloped area would be 19.2 km from a surfaced road and 8.0 km from any road.
- Every town with population above 2000 in plains and above 1000 in semi-hill areas and above 500 in hilly areas is to be connected by a surfaced road.
- Length of railway track is considered independent of the road system and hence is not subtracted to get the road length.
- Expressways have also been considered in this plan and 1600 km of length has been included in the proposed target of National Highways

#### THIRD TWENTY YEAR ROAD DEVELOPMENT PLAN 1981-2001

##### POLICIES AND OBJECTIVES

- (a) The future road development should be based on the revised classification of road system consisting of primary, secondary, and tertiary road systems.
- (b) The road net work should be developed so as to preserve the rural oriented economy and to develop small towns with all the essential facilities. All the villages with population over 500 (based on 1981 census) should be connected by all weather roads by the end of this century
- (c) The overall road density in the country should be increased to 82 km per 100 sq km area by the year 2001. The corresponding values of planned road densities are 40 for hill areas of altitude up to 2100 m above MSL and 15 km per sq km area for altitude above 2100m
- (d) The national highway network should be expanded to form square grids of 100 km sides so that no part of country is more than 50km away from NH

- (e) The lengths of SH and MDR required in a state or region should be decided based on both areas and number of towns with population above 5,000 in the state or region
- (f) Expressways should be constructed along major traffic corridors to provide fast travel
- (g) All the towns and villages with population over 1500 should be connected by Major District Roads and the villages with population 1000 to 1500 by Other District Roads. There should be a road within a distance of 3.0 km in plains and 5.0 km in hilly terrain connecting all villages or groups of villages with ' population less than 500
- (h) Roads should also be built in less industrialized areas to attract the growth of industries
- (i) Long term master plans for road development should be prepared at various levels, taluk, district, state and national levels. The road net work should be scientifically decided to provide maximum utility
- (j) The existing roads should be improved by rectifying the defects in the road geometries, widening of the pavements, improving the riding quality of the pavement surface and strengthening of the pavement structure to save vehicle operation cost and thus to conserve energy
- (k) There should be improvements in environmental quality and road safety

#### NATIONAL HIGHWAYS DEVELOPMENT PROJECTS

- The total length of various categories of roads in the Country as per the target of the third 20 - year road development plan 1981 - 2001 was 27,00,000 km.
- A higher road length of 31,76,000 km was achieved by the year 2000 itself.
- However the length of National Highways achieved was only 57,700 km as against the target of 66,000 km and the length of State Highways achieved was only 1,24,300 km as against the target of 1,45,000 km
- Realizing the deficiencies in the national highway system in the country, the National Highways Authority of India (NHAI) took up the National Highways Development Projects (NHDP) by the year 2000, in different phases.
- Phase - I of NHDP is called the 'Golden Quadrilateral of total length 5846 km connecting the four major metropolitan cities.
- The four sides of the quadrilateral are, (i) Delhi-Mumbai. (ii) Mumbai-Chennai (via Bangalore), (iii) Chennai - Kolkata and (iv) Kolkata-Delhi
- This project was started in December 2000 and was planned to be completed in six years.
- Phase - II of NHDP consists of,
  - (a) North - South corridor connecting Srinagar to Kanyakumari and
  - (b) East - West corridor connecting Silchar to Porbandar, of total length 7,300 km.
- Further development of selected stretches of national highways was planned in phases III, IV and V.

- Development of expressways was planned as phase VI and improvements of urban road networks as phase VII.

#### KARNATAKA ROAD DEVELOPMENT CORPORATION LIMITED (KRDCL)

- Karnataka Road Development Corporation (KRDCL) was incorporated on 21st of July 1999 as a wholly owned Government of Karnataka Company as per the Provisions of the Company's Act, 1956.
- KRDCL is a company under the Public Works, Ports & Inland Water Transport Department.
- This Company was established to promote surface infrastructure by taking up Road Works, Bridges etc., and to improve road network by taking up construction widening and strengthening of roads, construction of bridges, maintenance of roads etc., and to take up projects on BOT, BOOT, BOLT.
- KRDCL has taken up construction/reconstruction of bridges on SH's and MDR's through out Karnataka in 4 phases.

Phase I: completed

Phase II: Advanced stage of completion

Phase III & IV: Under progress

- KRDCL has taken up widening and up-gradation of State highways for a length of 1,055 Kms, out of which a length of 601 Kms has been completed already.
- State Highway Maintenance for 7300 Kms in Phase-I (2001-04) is completed.
- Maintenance for 14500 Kms in Phase-II (2005-08) is under progress
- KRDCL is administering some of the improvement works to the roads being executed by PWD
- Since inception Karnataka Road Development Corporation Limited has tried to improve the road network and to establish connectivity to all the corner of the State.

#### KARNATAKA STATE HIGHWAYS IMPROVEMENT PROJECT (KSHIP)

- Karnataka State Highways Improvement Project (KSHIP) is a road upgrading and rehabilitation initiative by Government of Karnataka under the World Bank loan to undertake improvement of 3411 km of roads consisting of State Highways and Major District Roads.
- Based on the Feasibility study, Government of Karnataka has selected 269 Km of roads for up gradation in a phased manner under KSHIP-II
- The total estimated project cost is 650.75 Crores.
- Aims to improve the core road network in Karnataka (SH + MDR with heavy traffic)
- The project will produce the following outputs:

- It will enhance the capacity and quality of the core state highway network;
- It provides safer transit on selected corridors;
- It improves allocation and provide adequate funding for the road sector;
- It provides more efficient and effective network management and delivery of road infrastructure services.

The project has four components:

- 1) upgrading and widening about 1000 km of priority state roads;
- 2) rehabilitating about 1300 km of state roads;
- 3) supporting the implementation of the Institutional Development
- 4) supporting a pilot safety program

- The project finances civil works for consultancies for advisory services, training, construction supervision, project management, system development and implementation;
- The estimated costs for physical works include the base cost, supervision, land acquisition, rehabilitation.

#### ROAD DEVELOPMENT PLANS - VISION DOCUMENTS (2021)

- The total length of NH achieved was 57,700 km as against the target of 66,000 km and that of SH achieved was 1,24,300 km as against the target of 1,45,000 km.
- The total target length of (MDR+ODR+VR) was 24,89,000 km whereas the actual achievement was 29,94,000 km.
- The overall total target road length (all categories of roads) of 27,00,000 km the total length achieved was 31,76,000km.
- The total target length of primary and secondary road system to be achieved in the country by the year 2020 are given below
  - (a) Primary highway system consisting of 15,766 km of expressways and 80,000 km of national highways.
  - (b) Secondary road system consisting of 1,60,000 km of state highways and 3,20,000 km of major district roads.
- The above document also has given special attention for road development needs in North-Eastern region and other isolated areas.
- In view of rapid growth rate of urban centers, some suggestions have been made for development of urban road system also.
- Tertiary system of rural roads consisting of other district roads and village roads are to be developed in order to provide all-weather road connectivity to all the villages of the country in a phased manner.

## PRADHAN MANTRI GRAM SADAK YOJANA

- An accelerated village road development programme called 'Pradhan Mantri Gram Sadak Yojana' (PMGSY) was launched by the central government in December 2000 to provide village connectivity with all-weather road.
- The Ministry of Rural Development was invested with the responsibility to prepare the master plans in consultation with the state governments.
- The objective of PMGSY is to provide connectivity to all unconnected habitations having population of 500 and above with all-weather roads.
- The above population limit is relaxed in the case of hills, tribal and desert areas of the country.

## RURAL ROAD DEVELOPMENT PLAN: VISION 2025

- A separate document 'Rural Road Development Plan Vision 2025' has been prepared for the 20 - year period 2005 — 2025 at the initiative of the Ministry of Rural Development, government of India.
- District-wise rural road development plans have been prepared.
- This vision document targets to provide connectivity to all unconnected habitations of the country in a phased manner, beyond the norms laid down in the PMGSY.
- It provides basic access to villages in phases: Phase - I, villages with population above 1000 Phase - II, villages with population above 500 Phase - III, villages with population below 500
- Lower population limits were fixed for wider developed regions including hills, deserts and tribal areas.

\* **NOTE:** Refer class notes for numericals solved on saturation system and 3<sup>rd</sup> 20 yr road development plan