

HIGHWAY ENGINEERING (15CV63)**As per Choice Based Credit System (CBCS) Scheme****MODULE – 1**

Principles of Transportation Engineering: Importance of transportation, Different modes of transportation and comparison, Characteristics of road transport Jayakar committee recommendations, and implementation – Central Road Fund, Indian Roads Congress, Central Road Research Institute

Highway Development and Planning: Road types and classification, road patterns, planning surveys, master plan – saturation system of road planning, phasing road development in India, problems on best alignment among alternate proposals Salient Features of 3rd and 4th twenty year road development plans and Policies, Present scenario of road development in India (NHDP & PMGSY) and in Karnataka (KSHIP & KRDC) Road development plan - vision 2021.

MODULE – 2

Highway Alignment and Surveys: Ideal Alignment, Factors affecting the alignment, Engineering Surveys-Map study, Reconnaissance, Preliminary and Final location & detailed survey, Reports and drawings for new and re-aligned projects

Highway Geometric Design: Cross sectional elements–width, surface, camber, Sight distances–SSD, OSD, ISD, HSD, Design of horizontal and vertical alignment–curves, super-elevation, widening, gradients, summit and valley curves

MODULE – 3

Pavement Materials: Subgrade soil - desirable properties-HRB soil classification-determination of CBR and modulus of subgrade reaction with Problems Aggregates- Desirable properties and tests, Bituminous materials- Explanation on Tar, bitumen, cutback and emulsion-tests on bituminous material

Pavement Design: Pavement types, component parts of flexible and rigid pavements and their functions, ESWL and its determination (Graphical method only)-Examples

MODULE – 4

Pavement Construction: Design of soil aggregate mixes by Rothfuch's method. Uses and properties of bituminous mixes and cement concrete in pavement construction. Earthwork; cutting and Filling, Preparation of subgrade, Specification and construction of

- 1) Granular Sub base,
- 2) WBM Base,
- 3) WMM base,
- 4) Bituminous Macadam,
- 5) Dense Bituminous Macadam
- 6) Bituminous Concrete,
- 7) Dry Lean Concrete sub base and PQC
- 8) Concrete Roads

MODULE – 5

Highway Drainage: Significance and requirements, Surface drainage system and design Examples, sub surface drainage system, design of filter materials, Types of cross drainage structures, their choice and location

Highway Economics: Highway user benefits, VOC using charts only-Examples, Economic analysis - annual cost method-Benefit Cost Ratio method-NPV-IRR methods- Examples, Highway financing-BOT-BOOT concepts

MODULE – 1

PRINCIPLES OF TRANSPORTATION ENGINEERING

INTRODUCTION

Basic Definition

A facility consisting of the means and equipment necessary for the movement of passengers or goods. At its most basic, the term “**Transportation System**” is used to refer to the equipment and logistics of transporting passengers and goods.

Importance of Transportation

The evolution and advancements in transportation facilities have been closely linked with the development of human beings throughout the history of the world.

Role of Transportation

Transportation plays a vital role in economic development of any region of any country, since every commodity produced, whether it may be agricultural or industrial products they need to be transported at various stages from production to distribution. At production stage for carrying raw materials and at distribution stage for transportation from farms and factories to marketing centers to retailers to consumers.

Inadequate transportation facilities retard the process of socio-economic and cultural development. Development of transportation facilities in a country indicates its economic growth and progress in social development.

The main objective of a good transportation system is to provide a safe, economical and efficient transportation facility for passengers and goods.

Economic Activity and Transport

These are the processes in which the products are utilized to satisfy human needs. Two important factors well known in economic activity are

- 1) Production or supply
- 2) Consumption for human needs or demands

Social Effects of Transportation

The progress of a nation depends on transportation facilities. The population usually settles along the transportation routes such as road sides, river shores and railway stations. However, in the present concept of road network planning the above said kind of ribbon development is discouraged for the sake of high speed travel and safety. Attempts are being made to decentralize the population away from main transportation routes.

To avoid congestion on major cities, suburbs and satellite towns are being developed and are linked to the major cities with mass rapid transit system.

The various social effects of transportation are

- a) Sectionalism and transportation
- b) Concentration of population in urban area
- c) Aspect of safety, law and order

a) Sectionalism and Transportation

- 1) Improved transportation has important implication in reducing sectionalism within the country and also with other countries in the world
- 2) The living conditions and facilities of under developed colonies and tribes get improved since the distances are apparently reduced with reduction in travel time.
- 3) Frequent travel to the other parts of the country and outside the country tend to increase knowledge of the people by learning from other sections of society which results in improved trade and cultural exchanges.
- 4) International understanding for the better peace and order also improves with efficient network of transportation.

b) Concentration of Population in Urban Areas

- 1) Improved transportation facilities bring prosperity to the urban population
- 2) The employment opportunities, prosperity and superior facilities for education, medical care etc., are available in urban areas attract the population from other areas leading to increased economic activities
- 3) Adequate mass transportation facilities are needed to cater for the internal movements for daily movements and other social needs
- 4) Effective rapid transportation facilities are needed for suburban and intercity long-distance travel

- 5) Inadequate transportation facilities lead to concentration of population in cities which often results in congestion and related issues.
- 6) If adequate facilities are provided people tend to prefer to reside at localities away from urban centers.

c) Aspect of safety, Law and order

- 1) Transportation facilities are required for rushing aid to areas affected by an emergency.
- 2) To maintain law and order and defend the territory of the country against external aggression and to guard borders with foreign territory transportation facilities are needed.
- 3) Sometimes defense needs alone are a sufficient reason to develop transportation needs which may not have any social and economic benefits.

Role of Transportation for the Development of rural areas in India

About 70% of population in India are living in rural areas. Therefore, development in urban centers alone do not indicate overall development of the country. Only with the improvements in transportation facilities in rural areas, there could be faster development of these areas, resulting in overall development of country.

Impacts of rural roads connectivity from rural road development in India

- 1) Improvements in transportation services leads to improved access to market centers for the rural producers, better availability of farm inputs at reduced prices.
- 2) Diversification of agricultural produce with improved market access promotes shift in favor of cash crops and commercialization of agricultural activities.
- 3) Diversification of livelihood opportunities with better connectivity enhances employment opportunity with better connectivity enhances employment opportunities in non-agricultural sectors.
- 4) Improved services with improved road connectivity, inter-alia, enhances access to education, health and financial services.
- 5) Increase in outreach due to improved rural roads facilities better availability of public services and functionaries in rural areas.

DIFFERENT MODES OF TRANSPORTATION

Transportation has developed along three basic modes of transport

- a) Land
- b) Water
- c) Air

Land has given scope for development of transportation by road and rail transport. Water and air media have developed waterways and airways respectively. The roads or the highways not only include modern highway system but also includes the urban arterials, city streets, feeder roads and village roads catering for a wide variety of vehicles and pedestrians. Railways have been developed both for long distance travel and also urban travel. Waterways include transportation by oceans, rivers, canals and lakes for the movement of ships and boats. The airways help in faster transportation by aircrafts and carriers.

Apart from these major modes of transportation, other modes include pipelines, elevators, belt conveyors, cable cars, aerial ropeways and monorails. Pipe lines are used for the transportation of water, other fluids and even solid particles

The four major modes of transportation are:

- a) Roadways or highways for road transportation
- b) Railways for rail transportation
- c) Waterways for water transportation
- d) Airways for air transportation

ROADWAYS

The transportation by road is the only mode which could give maximum service to one and all. Road transport mode has the maximum flexibility for travel with reference to choice of the route, direction, time and speed of travel. This is 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 route. The other three modes (railways; water ways; airways) have to depend on transportation by road for the service to and from their respective terminals. Therefore, the roadway essentially serves as a feeder network. It is possible to provide door to door service by road transport. Ultimately, road network is therefore needed not only to serve as feeder system for other modes of transportation and to supplement them, but also to provide independent facility for road travel by a well-planned network of roads throughout the country

Advantages:

- 1) Flexibility: It offers complete freedom to the road users.
- 2) It requires relatively smaller investments and cheaper in construction with respect to other modes.
- 3) It serves the whole community alike the other modes.
- 4) For short distance travel, it saves time.
- 5) The road network is used by various types of vehicles.

Disadvantages:

- 1) Speed is related to accidents and more accidents results due to higher speed and is usually not suitable for long distance travel
- 2) Power required per tonne is more.

RAILWAYS

The concept of rail transportation is movement of multiple wagons or a train of wagons passenger's bogies on two parallel steel rails. The resistance to traction along the railway track for the movement of steel wheels is much lower than that along more uneven road surface for the movement of road vehicles with rubber tyres. The transportation along the railway track could be advantageous by railways between the stations both for the passengers and goods, particularly for longer distances. The energy requirement to haul unit load through unit distance by the railway is only a fraction (one fourth to one sixth) of the required by road. Hence, full advantage of this mode of transportation should be taken for the transportation of bulk goods along land where the railway facilities are available. The Indian railways is one of the world's largest Railway network in the world. It was introduced in 1853 and it is spread over 1,09,221 km covering 6906 stations.

Advantages:

- 1) Can transport heavy loads of goods at higher speed
- 2) Power required per tonne is less compared to roadways
- 3) Chances of accidents are less.

Disadvantages:

- 1) Entry and exist points are fixed
- 2) Requires controlling system and no freedom of movement
- 3) Establishment and maintenance cost is higher

WATERWAYS

Transportation by water offers minimum resistance to traction and therefore needs minimum energy to haul unit load through distance. The water transportation is the most energy efficient but it is the slowest among the four modes. The highest use of this mode is for bulk cargo of relatively low value. The transportation by water is possible between the ports on the sea routes or along the rivers or canals where inland transportation facilities are available.

Advantages:

- 1) Cheapest: Cost per tonne is lowest
- 2) Possess highest load carrying capacity
- 3) Leads to the development of the industries.

Disadvantages:

- 1) Slow in operation and consumes more time and Depends on whether condition
- 2) Chances of attack by other countries on naval ships are more.
- 3) Ocean tides affects the loading and unloading operation and the routes are circuitous.

AIRWAYS

The transportation by air is the fastest among the four modes. Air 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.

For shorter hauls helicopters are used and they were developed for their landing and takeoff. Military aviation is also important to meet the defense needs of a country.

Advantages

- 1) It has highest speed.
- 2) Intercontinental travel is possible
- 3) Journey is continuous over land and water

Disadvantages

- 1) Highest operating cost (cost/tonne is more) and the load carrying capacity is lowest
- 2) Depends on whether condition
- 3) Should follow the flight rules.

CHARACTERISTICS OF ROAD TRANSPORTATION

It is accepted that the fact 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 goods have to be first transported by road before reaching a railway station or an airport. The far-flung border areas located in high altitude and difficult terrains of the country and the remote villages in the under developed villages could be served by the road network. Road network is very economical and convenient for short road trips and even some times for longer trips.

The characteristics are of roads are as follows

- 1) Roads are used by various types of road vehicles like passenger, goods vehicles and pedestrians. But the rail locomotives and wagons can only make use of the railway track. The ships and boats can make use of only the waterways and the aircraft's only the airports.
- 2) Road transport infrastructure requires the lowest initial investments in comparison to that for the infrastructure of other transportation modes. The cost of any class of road of road vehicle is much lower is much lower than that of other carriers like the railways, ships and aircrafts. The initial cost of construction and the cost of maintenance of roads is also lesser than those for railway tracks, harbors and airports.
- 3) Roads offer complete freedom to the roads to the road user 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.
- 4) It is possible to travel directly from the respective places of origin to the destination by road vehicles.
- 5) Speed of movement is directly related with the severity of accidents. The road safety decreases with the increasing running speed dispersion in the traffic stream. Road transport is prone to a high rate of accidents due to the flexibility of movements offer to the road users. 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.
- 6) Road transport is the only mode that offers the facilities to the whole section of society.

JAYAKAR COMMITTEE RECOMMENDATIONS AND IMPLEMENTATION**RECOMMENDATIONS**

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

- 1) 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.
- 2) An extra tax should be levied on petrol from the road users to develop a road development fund called '**Central Road Fund**'
- 3) 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.
- 4) A research organization should be instituted to carry out research and development work pertaining to roads and to be available for consultations.

IMPLEMENTATIONS:

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

Some of the technical bodies were formed such as,

- 1) Central Road Fund (CRF) in 1929
- 2) Indian Road Congress (IRC) in 1934
- 3) Central Road Research Institute (CRRI) in 1950.

CENTRAL RESEARCH FUND (CRF):

- 1) Central Research Fund (CRF) was formed on 1st March 1929
- 2) The consumers of petrol were charged an extra levy of 2.64 paisa/liter of petrol to build up this road development fund.
- 3) From the fund collected 20 percent of the annual revenue is to be retained as meeting expenses on the administration of the road fund, road experiments and research on road and bridge projects of special importance.
- 4) The balance 80 percent of the fund to be allotted by the Central Government to the

various states based on actual petrol consumption or revenue collected

- 5) The accounts of the CRF are maintained by the Accountant General of Central Revenues.
- 6) The control of the expenditure is exercised by the Roads Wings of Ministry of Transport.

INDIAN ROAD CONGRESS (IRC):

- 1) It is a semi-official technical body formed in 1934. It was formed to recommend standard specifications.
- 2) It was constituted to provide a forum of regular technical pooling of experience and ideas on all matters affecting the planning, construction and maintenance of roads in India.
- 3) IRC has played an important role in the formulation of the 20-year road development plans in India.
- 4) Now, it has become an active body of national importance controlling specifications, guidelines and other special publications on various aspect of Highway Engineering.

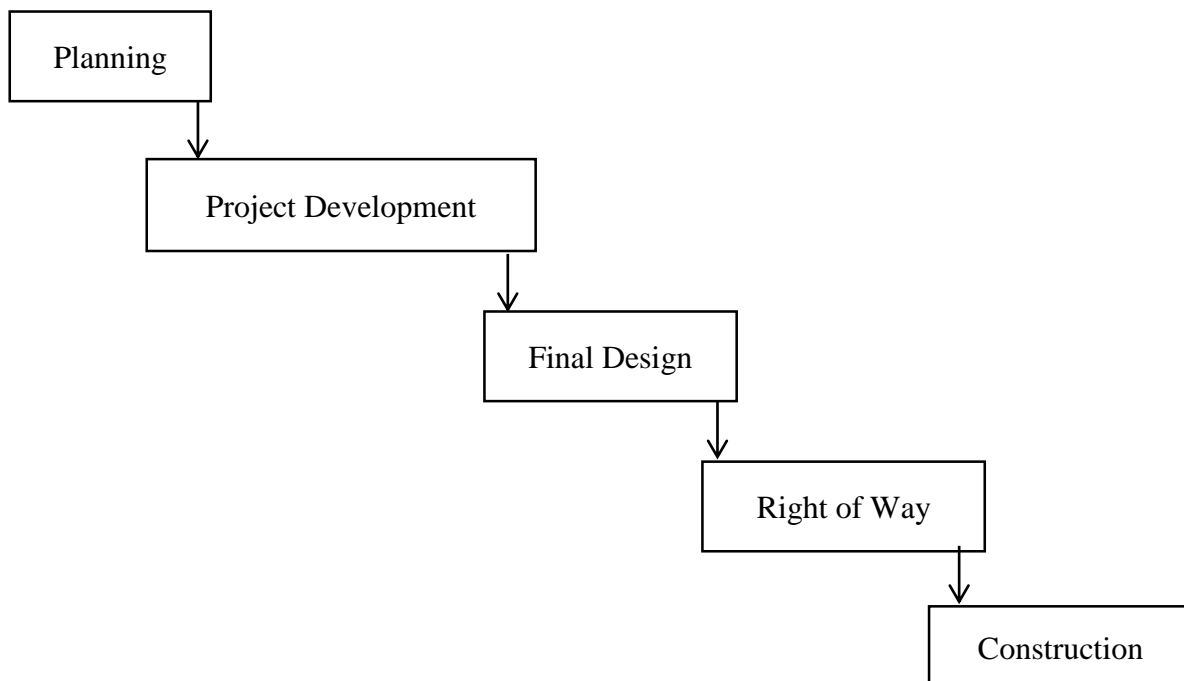
CENTRAL ROAD RESEARCH INSTITUTE (CRR):

- 1) CRR was formed in the year 1950 at New Delhi
- 2) It was formed for research in various aspect of highway engineering
- 3) It is one of the National laboratories of the Council of Scientific and Industrial Research.
- 4) This institute is mainly engaged in applied research and offers technical advice to state governments and the industries on various problems concerning roads.

HIGHWAY DEVELOPMENT AND PLANNING**INTRODUCTION**

Highway design is only one element in the overall highway development process. Historically, detailed design occurs in the middle of the process, linking the preceding phases of planning and project development with the subsequent phases of right-of-way acquisition, construction, and maintenance. While these are distinct activities, there is considerable overlap in terms of coordination among the various disciplines that work together, including designers, throughout the process.

It is during the first three stages, planning, project development, and design, that designers and communities, working together, can have the greatest impact on the final design features of the project. In fact, the flexibility available for highway design during the detailed design phase is limited a great deal by the decisions made at the earlier stages of planning and project development. This Guide begins with a description of the overall highway planning and development process to illustrate when these decisions are made and how they affect the ultimate design of a facility.



Objectives of Highway Planning

Planning is considered as pre-requisite before attempting any development program in the present era. Highway planning is of great importance when funds available are limited whereas the total planning is of great importance when the funds are limited whereas the total requirement is much higher. The objectives are as follows

- a) To plan the overall road network for efficient and safe traffic operations, but at minimum cost. Here the costs of construction, maintenance and resurfacing or strengthening of pavement layers and vehicle operation costs are taken into 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 construction
- 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 program.
- e) To plan for the future requirements and improvements of roads in view of anticipated developments.
- f) To work out suitable financing systems

Phases of Highway Planning

Highway planning includes the following phases

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

MEANING OF HIGHWAY AND ROAD

Road: A **road** is a thoroughfare, route or way on land between two places, which typically has been paved or otherwise improved to allow travel by some conveyance, including a horse, cart, or motor vehicle.

Highway: A **highway** is a public road, especially a major road connecting two or more destinations. Any interconnected set of highways can be variously referred to as a "highway system", a "highway network", or a "highway transportation system". Each country has its own national highway system.

CLASSIFICATION OF ROADS

Types of Roads

Basically, different types of roads can be classified into two categories namely,

- a) All-weather roads and
- b) Fair-weather roads.

All-weather roads: These roads are negotiable during all weather, except at major river crossings where interruption of traffic is permissible up to a certain limit extent, the road pavement should be negotiable during all weathers.

Fair-weather roads: On these roads, the traffic may be interrupted during monsoon season at causeways where streams may overflow across the roads.

a) Based on the Carriage Way

- **Paved Roads:** These are the roads which have a hard pavement surface on the carriage way
- **Unpaved Roads:** These are the roads without the hard pavement surface on the carriage way, usually they are earthen or gravel roads.

b) Based on Surface Pavement Provided,

- **Surface Roads:** These roads are provided with any type of bituminous or cement concrete surfacing.
- **Unsurfaced Roads:** These roads are not provided with a bituminous or cement concrete surfacing.

Roads which are provided with bituminous surfacing are called as **Black Toped Roads** and that of concrete are referred to as **Concrete Roads** respectively

Methods of Classification of Roads

The roads are generally classified based on the following

- a) Traffic Volume
 - b) Load transported of tonnage
 - c) Location and function
- a) **Based on Traffic Volume:** The classification based on traffic volume or tonnage have been arbitrarily fixed by different agencies and are classified as
- Heavy
 - Medium
 - Light traffic roads
- b) **Based on Load transported or tonnage:**
- Class-I or Class-A
 - Class-II or Class-B.
- c) **Based on location and Function:**
- The Nagpur Road Plan classified the roads in India into the following categories
- 1) **National Highways (NH):** The NH connects the capital cities of the states and the capital cities to the port. The roads connecting the neighboring countries are also called as NH. The NH are at least 2 lanes of traffic about 7.5m d wide. The NH are having concrete or bituminous surfacing.
 - 2) **State Highways (SH):** SH are the main roads within the state and connect important towns and cities of state. The width of state highways is generally 7.5m.
 - 3) **Major District Roads (MDR):** These roads connect the areas of production and markets with either a SH or railway. The MDR should have at least metaled single lane carriage way (i.e., 3.8m) wide. The roads carry mixed traffic.
 - 4) **Other District Roads (ODR):** these roads connect the village to other village or the nearest district road, with ghat, river etc. these roads have a single lane and carry mixed traffic.
 - 5) **Village Roads (VR):** these roads, like other district roads, connect the village or village or nearby district road. The roads carry mixed traffic.

Modified Classification of Road System by Third Road Development Plan

The road classification system was modified in the third 20-year development plan. The roads are now classified into three classes and are as follows

1. Primary System
 - Expressways
 - National Highways (NH)
2. Secondary System
 - State Highways (SH)
 - Major District Roads (MDR)
3. Tertiary System
 - Other District Roads (ODR)
 - Village Roads

Classification of Urban Roads

The road system within urban areas are classified as Urban Roads and will form a separate category of roads taken care by respective urban authorities. The lengths of urban roads are not included in the targets of the 3rd 20-year road development plan 1981-2001.

- a) Arterial roads
 - b) Sub-arterial roads
 - c) Collector Streets
 - d) Local Streets
- Arterial and Sub-arterial roads are primarily for through traffic on a continuous route, but 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.

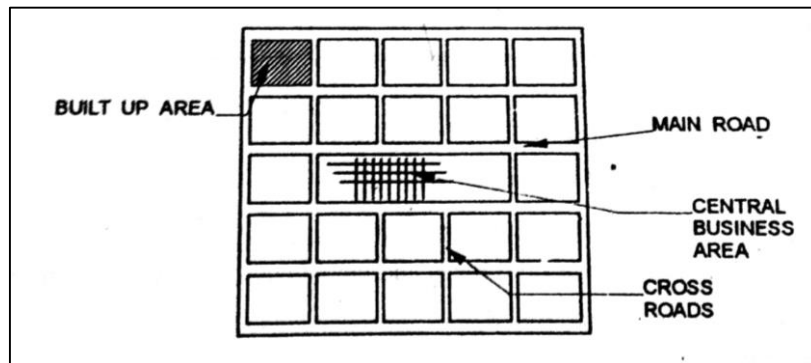
ROAD PATTERNS

There are various types of road patterns and each pattern has its own advantages and limitations. The choice of the road pattern depends upon the various factors such as:

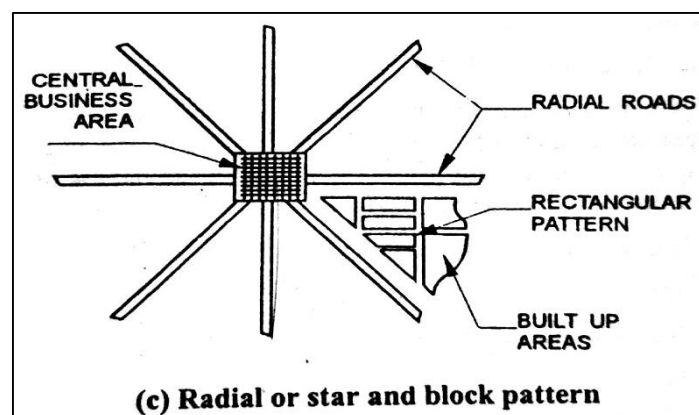
- Locality
- Layout of the different towns, villages, industrial and production centers.
- Planning Engineer.

The various road patterns may be classified as follows:

- 1) **Rectangular or block pattern:** In this, entire area is divided into rectangular segments having a common central business and marketing area. This area has all the services located in the central place. This pattern is not convenient or safe from traffic operation point of view and it results into more number of accidents at intersections. E.g.: Chandigarh city.

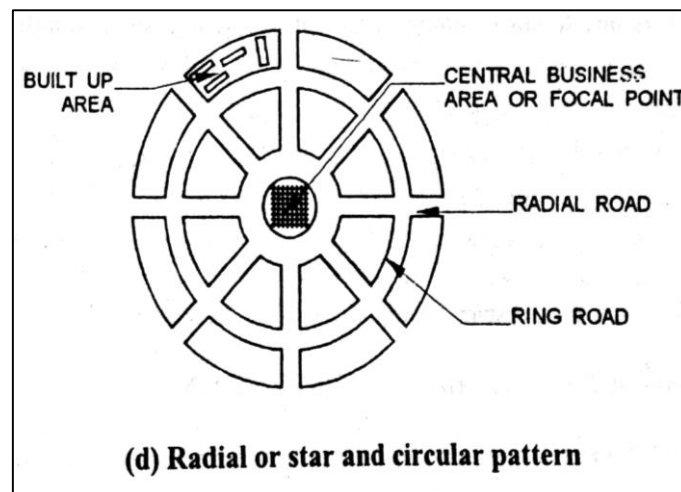


- 2) **Radial or star and block pattern:** In this, roads radially emerge from the central business area in all directions and between two built-up area will be there. The main advantage in this, central place is easy accessible from all the directions. E.g.: Nagpur

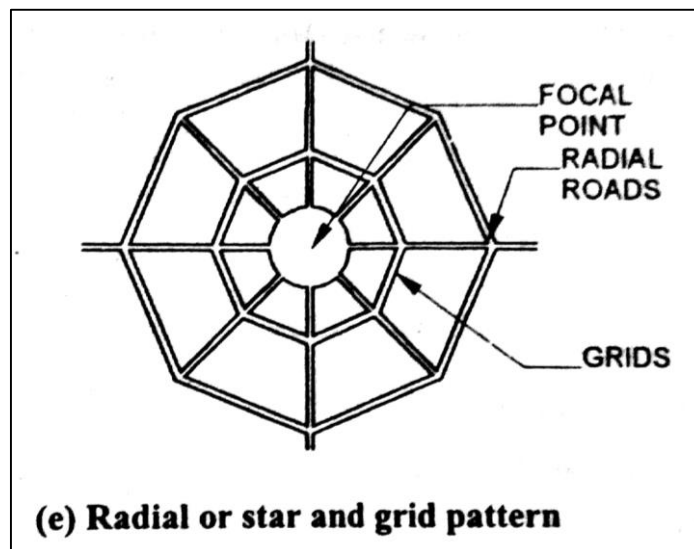


- 3) **Radial or star and circular pattern:** In this road radiate in all the directions and also circular ring roads are provided.

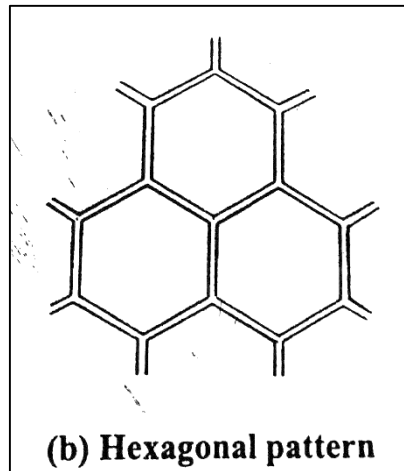
Advantages: Traffic will not touch the heart of the city and it flows radially and reaches the other radial road and thereby reducing the congestion in the center of the city. This ring road system is well suited for big cities where traffic problems are more in the heart of the city. E.g.: Connaught place in New Delhi.



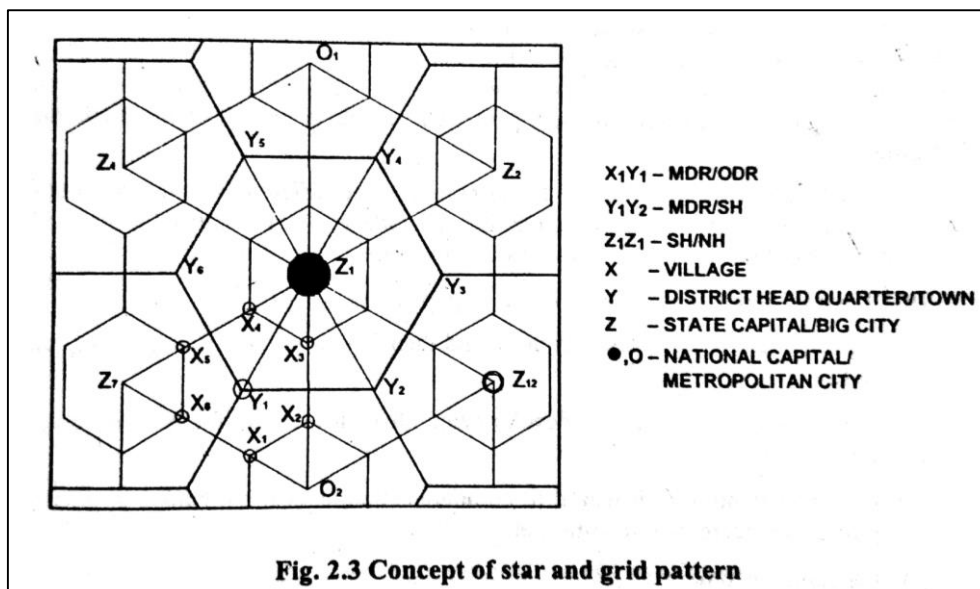
- 4) **Radial or star and grid pattern:** It is very much similar to star and the circular pattern excepts the radial roads are connected by grids. In this pattern, a grid is formed around the central point which is a business center. E.g. Nagpur road plan.



- 5) **Hexagonal pattern:** In this entire zone of planning is divided into hexagonal zones having separate marketing zone and central services surrounded by hexagonal pattern of roads. Each hexagonal element is independent. At each corner of hexagon three roads meet.



- 6) **Minimum travel pattern:** In this type, city is divided into number of nodal points around a central portion by forming sectors. And each sector is divided again in such a way that from each of the nodal center, the distance to the central place is minimum.



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 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.

Objectives of Planning Surveys:

- Workout, the financial system and recommended changes in tax arrangements and budget procedures, provide efficient, safe economics, comfortable and speedy movement for goods and people.
- Plan a road network for efficient traffic operation at minimum cost.
- Plan for future requirements and improvements of roads in view of developments and social needs.
- Fix up data wise priorities for development of each road link based on their utilities.

The planning surveys consist of the following studies:

a) Economic Studies

The details to be collected during the economic studies are useful in estimation of the requirements, cost involved for the proposed highway improvement programme and economic justification.

This study consists the following details:

- a) Population and its distribution
- b) Trend of population growth
- c) Age and land products
- d) Existing facilities
- e) Per Capita income.

b) 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. This study involves collecting the details such as:

- a) Sources of income
- b) Living Standards
- c) Resources from local levels
- d) Factor trends in financial.

c) 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 movements, existing facilities for mass transportation, trend in road accidents, accidents costs etc. The detail collected are as follows

- a) Classified traffic volume in vehicles per day, annual average daily traffic, peak and design hourly volume
- b) Origin and destination studies based on home interview method
- c) Traffic flow pattern
- d) Mass transportation facilities
- e) Accidents, their causes and cost analysis
- f) Future trend and growth in traffic volume and goods traffic, trend in traffic pattern
- g) Growth of passenger trips and the trend in the choice of modes

d) Engineering Studies

All the details of the topography, soil and drainage characteristics, alignment of the existing roads, deficiencies in drainage, alignments and geometrics of existing roads and requirements of essential upgradation, identification of maintenance and problems etc.,

This involves:

- a) Topographic study and Soil details
- b) Location and classification of existing roads

- c) Assessment of various other developments in the area that are likely due to the proposed highway development
- d) Road life studies
- e) Specific problems in drainage constructions and maintenance.

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 program, the information collected during the fact-finding studies are presented in the form of various plans. They are as follows

Plan-1: General area plan showing most of the existing details about the topographical details related to existing road network, drainage, structures, towns and villages with population, agricultural, industrial and commercial activities.

Plan-2: Plan showing the distribution of population groups in accordance with the categories made in appropriate plan.

Plan-3: Plan showing the locations of places with their respective quantities of productivity.

Plan-4: Should indicate the existing network of roads and proposals received.

Ultimately, the Master plan is the one to be implemented.

MASTER PLAN

Master plan is referred to as road development plan of a city; district or a street or for whole country. It is an ideal plan showing full development of the area at some future date. It serves as the guide for the plan to improve some of the existing roads and to plan the network of new roads.

It helps in controlling the industrial, commercial and agricultural and habitat growth in a systematic way of that area. It gives a perceptive picture of a fully developed area in a plan and scientific way.

Stages in the preparation of master plan:

- Data Collection: It includes data regarding existing land use, industrial and agricultural growth, population, traffic flow, topography, future trends.
- Preparation of draft plan and invite suggestions and comments from public
- Revision of draft plan in view of the discussions and comments from experts and public.
- Comparison of various alternate proposals of road system and finding out the sequence in which the master plan will be implemented.

In India, targeted road lengths were fixed in various road plans, based on population, area and agricultural and industrial products. The same way it may be taken as a guide to decide the total length of road system in each alternate proposal while preparing a master plan for a town or locality.

SATURATION SYSTEM

In this system optimum road length is calculated for an area based on the concept of attaining maximum utility per unit length of the road. This is also called as **MAXIMUM UTILITY SYSTEM**.

Factors to attain maximum utility per unit length are:

- a) Population served by the road network
- b) Productivity served by the network
 - Agricultural Products
 - Industrial Products

The various steps to be taken to obtain maximum utility per unit length are:

- 1) **Population factors or units:** Since, the area under consideration consists of villages and towns with different population these are grouped into some convenient population range and some reasoning values of utility units to each range of population serve are assigned.
 - a) Population less than 500, utility unit = 0.25
 - b) 501 to 1001, utility unit = 0.50
 - c) 1001 to 2000, utility unit = 1.00
 - d) 2001 to 5000, utility unit = 2.00 etc.
- 2) **Productivity Factors or units:** The total agricultural and industrial products served by each road system are worked out and the productivity served may be assigned appropriate values of utility units per unit weight.
- 3) **Optimum Road length:** Based on the master plan the targeted road length is fixed for the country on the basis of area or population and production or both. And the same may be taken as a guide to decide the total length of the road system in each proposal.

Problems in Class Notes

PHASING ROAD DEVELOPMENT IN INDIA

The first attempt for proper planning of the highway development programme in India on a long-term basis was made at the Nagpur Conference in 1943. After the completion of the Nagpur Road Plan targets, the Second Twenty year Plan was drawn for the period 1961- 1981. The Third Twenty Year Road Development Plan for the period 1981-2001 was approved only by the year 1984.

The fourth 20-year road development plan of the country for the period 2001 – 2021 has not yet been approved as an official plan document, instead ‘Roads Development Vision: 2021’ has been formulated.

First 20-Year Road Plan (Nagpur Road plan)

This plan was formed in the year 1943 at Nagpur and plan period was from 1943- 1963. Two plan formulae were finalized at the Nagpur Conference for deciding two categories of road length for the country as a whole as well as for individual areas (like district). This was the first attempt for highway planning in India. The two plan formulae assumed the Star and Grid pattern of road network. Hence, the two formulae are also called “Star and Grid Formulae”.

Salient Features of Nagpur Road Plan

All the roads were classified into 5 categories namely

- 1) National Highways (NH)
- 2) State Highways (SH)
- 3) Major District Roads (MDR)
- 4) Other District Roads (ODR)
- 5) Village Roads (VR)

Two plan formulas were suggested for deciding the length of two categories of roads as given below

Category – 1: Surfaced or metaled roads meant for NH/SH/MDR

Category – 2: Unsurfaced roads meant for ODR/VR

Nagpur road plan aimed at achieving a modest average road density of 16km per km² area.

Second Twenty Year Road Plan (Bombay Road Plan):

As the target road length of Nagpur road plan was completed nearly earlier in 1961 a long-term plan was initiated for twenty-year period which was initiated by IRC. Hence, the second twenty year road plan came into picture which was drawn for the period of 1961-81. The second twenty year road plan was envisaged overall road length of 10, 57,330 km by the year 1981.

Salient Features of Second 20-year Road Plan:

- Every town with population above 2000 in plains should be connected by a bituminous road or metaled road, above 1000 in semi-hilly area above 500 in hilly area
- 1600 km length of expressways was proposed.
- Development allowance is 5% only
- Length of railway track was not deducted.
- Five equations are given to find NH/SH/MDR/ODR/VR.

Third Twenty Year Road Plan (Lucknow Road Plan):

The Third twenty year road plan was prepared by the Road Wing of the Ministry of Shipping and Transport with the active co-operation from a number of organizations and the experts in the field of Highway Engineering and Transportation. This document was released during the 45th Annual Session and the Golden Jubilee celebrations of the Indian Road Congress in February 1985 at Lucknow. Therefore, this plan for 1981-2001 is also called as '**Lucknow Road Plan**'.

Salient Features of Second 20-year Road Plan

- The future road development should be based on the revised classification of road system consisting of Primary, secondary and tertiary systems.
- The road network should be developed so as to preserve the rural oriented economy and to develop small to towns with all the facilities. All the villages with population above 500 should be connected with all-weather roads by the end of the century.
- The overall road density should be increased to 82 km per 100 sq. km area by the year 2001 and 40km for hill areas of altitude up to 2100m and 15km for altitude over 2100m.
- The NH network should be expanded to form square grids of 100km sides so that no part of the country in more than 50km away from a NH
- The length of SH and MDR required should be decided based on the areas and no. of towns with population above 5000 in the state or region.
- Expressway should be constructed along the major traffic corridors to provide fast travel.
- All the towns and villages with population above 1500 should be connected by MDR and villages with population 1000 to 1500 by ODR. There should be road within a distance of 3km in plain and 5km in hilly terrain connecting the villages with population less than 500.

- Roads should be built in less industrialized areas to attract the growth of industries.
- Long term master plans for road development should be prepared at various level i.e., taluk, district, state and national level. The road network should be scientifically decided to provide maximum utility.
- The existing roads should be improved by rectifying the defects in the road geometrics, widening of the pavements, improving the riding quality of the pavement surface and strengthening of pavement structure
- There should be improvements in environmental quality and road safety.

Road length by 3rd 20-year road development plan

a) Length of NH – 1km per 50sq. km area.

b) Length of SH

1) By total area – SH, km = Area of the state, sq.km/25

2) By total no of town and area in the state, SH, km =

$$\frac{(62.5 \times \text{No towns in the state} - \text{area of the state, sq. km})}{50}$$

Adopt length of SH (higher of the two criteria)

c) Length of MDR

1) By total area – MDR, km = Area of the state, sq.km/12.5

2) By total no of town and area in the state, MDR, km = 90 x No. of towns in the state.

Adopt length of SH (higher of the two criteria).

PRESENT SCENARIO OF ROAD DEVELOPMENT IN INDIA

NATIONAL HIGHWAY DEVELOPMENT PROJECTS (NHDP)

- Realizing the deficiencies in the National Highway System in the country the National Highways Authorities of India (NHAI) took up the National Highways Development Projects (NHDP) by the year 2000 in different phases
- The **National Highways Development Project** (NHDP) is a project to upgrade, rehabilitate and widen major highways in India to a higher standard.
- The project was started in 1998 under the leadership of then Prime Minister, Atal Bihari

Vajpayee. National Highways account for only about 2% of the total length of roads, but carry about 40% of the total traffic across the length and breadth of the country.

- This project is managed by the National Highways Authority of India (NHAI) under the Ministry of Road, Transport and Highways.
- The NHDP represents 49,260 km of roads and highways work and construction in order to boost economic development of the country.
- The government has planned to end the NHDP program in early 2018 and consume the ongoing projects under a larger Bharatmala project.

Phase I: Golden Quadrilateral of total length 5846km connecting the 4 major metropolitan cities. The four sides of the quadrilateral are Delhi – Mumbai, Mumbai – Chennai (Via Bengaluru), Chennai – Kolkata and Kolkata- Delhi.

Phase II: North-South and East-West corridors comprising national highways connecting four extreme points of the country. The North–South and East–West Corridor (NS-EW; 7,142 km) connecting Srinagar in the north to Kanyakumari in the south, and Silchar in the east to Porbandar in the west. Total length of the network is 7,142 km.

Phase III: The government on 12th April, 2007 approved NHDP-III to upgrade 12,109 km (7,524 mi) of national highways on a Build, Operate and Transfer (BOT) basis, which takes into account high-density traffic, connectivity of state capitals via NHDP Phase I and II, and connectivity to centers of economic importance.

Phase IV: The government on 18th June, 2008 approved widening 20,000 km of highway that were not part of Phase I, II, or III. Phase IV will convert existing single-lane highways into two lanes with paved shoulders.

Phase V: As road traffic increases over time, a number of four-lane highways will need to be upgraded/expanded to six lanes. On 5 October, 2006, the government approved for upgrade of about 5,000 km (3,100 mi) of four-lane roads.

Phase VI: The government is working on constructing 1,000 km (620 mi) expressways that would connect major commercial and industrial townships. It has already identified 400 km (250 mi) of Vadodara (earlier Baroda)-Mumbai section that would connect to the existing Vadodara (earlier Baroda)-Ahmedabad section. The World Bank is studying this project. The project will be funded on BOT basis. The 334 km (208 mi) Expressway between Chennai—Bangalore and 277 km (172 mi) Expressway between Kolkata—Dhanbad has been identified and feasibility study and DPR contract has been awarded by NHAI.

Phase VII: This phase calls for improvements to city road networks by adding ring roads to enable easier connectivity with national highways to important cities. In addition, improvements will be made to stretches of national highways that require additional flyovers and bypasses given population and housing growth along the highways and increasing traffic. The government has planned to invest Rs. 16,680 Cr for this phase. The 19 km (12 mi) long Chennai Port—Maduravoyal Elevated Expressway is being executed under this phase.

PRADHAN MANTRI GRAM SADAK YOJANA (PMGSY)

- An accelerated village road development called Pradhan Mantri Gram Sadak Yojana was launched by the Govt. of India in Dec 2000 under the guidance of Ex. Prime Minister Shri Atal Bihari Vajapayee to provide villages with all-weather roads.
- The ministry of Rural Development was given the responsibility to prepare the master plans in consultation with the State Governments.
- The objective of PMGSY was to provide connectivity to all unconnected habitations having a 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.
- The Pradhan Mantri Gram Sadak Yojana (PMGSY) is a 100% Centrally Sponsored Scheme. 0.75₹/ litre out of the Cess on High Speed Diesel (HSD) is earmarked for this Programme.

PROGRAMME OBJECTIVES

- 1) The primary objective of the PMGSY is to provide Connectivity, by way of an All-weather Road (with necessary culverts and cross-drainage structures, which is operable throughout the year), to the eligible unconnected Habitations in the rural areas with a population of 500 persons and above in Plain areas.
- 2) In respect of the Hill States (North-East, Sikkim, Himachal Pradesh, Jammu & Kashmir and Uttarakhand), the Desert Areas (as identified in the Desert Development Programme), the Tribal (Schedule V) areas and Selected Tribal and Backward Districts (as identified by the Ministry of Home Affairs and Planning Commission).
- 3) The objective would be to connect eligible unconnected Habitations with a population of 250 persons and above.

KSHIP

- The **Karnataka State Highways Improvement Project (KSHIP)** is an initiative of the Public Works Department of the Government of Karnataka for improvement of road network of the state with World Bank assistance.
- The Public Works Department carried out Strategic Option Study (SOS) during 1996 on a road network of 13,362 km comprising State Highways and Major District Roads and the study identified 2888 km of roads for prioritized improvements.
- The World Bank have extended Technical Assistance (T.A.) Loan of US \$ 3.2 million for project preparation through the Department of Economic Affairs of Ministry of Finance, Government of India for taking up the Project Coordinating Consultancy (PCC) Services to investigate and prepare detailed project report on the 2888 km and Institutional Development Strategy (IDS) Study.
- With concurrence of the World Bank, M/s. Scott Wilson Kirkpatrick, United Kingdom were selected and appointed on 07-01-1999 to carryout PCC Services for 2505 km of roads.
- The PCC Services were divided into Phase I & II. The PCC Consultants carried out feasibility and social & environmental screening and identified 2271 km for prioritized improvement. It is proposed to undertake Upgradation of 992 Km and Rehabilitation of 1277 Km.

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.
- Since inception Karnataka Road Development Corporation Limited has strived to improve the road network and to establish connectivity to all the nook & corner of the State.

ROAD DEVELOPMENT PLAN: VISION 2021

- Actual achievement in terms of length of different categories of roads in the country at the end of the 3rd 20-year road development plan period was compared with the plan targets.
- It was observed that actual length of NH and SH achieved fell short of plan targets. The total length of NH achieved was 57,700km as against the target of 66,000km and that the SH achieved was 1,24,300km as against of 1,45,000km.
- This vision document has considered the need for overall development of road system in country. The total target length of primary and secondary road system to be achieved in the country by the year 2020 are given below
- Primary highway system consisting of 15,766km of expressway and 80,000km of NH
- Secondary road system consisting of 1,60,000 km of SH and 3,20,000km of MDR
- The above document also has given special attention for road development needs in North-Eastern regions and other isolated areas. In view of rapid growth rate of urban centres, some suggestion has been made for the development of urban road system also.
- Tertiary system of rural roads consisting of ODR and VR are to be developed in order to provide all-weather road connectivity to all the villages of the country in a phased manner. Considering the importance of this subject, a rural road development plan document was prepared.

Rural Road Development Plan: Vision 2025

It was developed for the 20-year period of 2005-2025 to provide 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 under developed regions including hills, deserts and tribal areas.