UNIT-1

Highway planning in India

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

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

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

Jayakar Committee:

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

Committee found that the road development in the country should be considered as national interest as this has become beyond the capacity of local governments and local bodies.

An extra tax should be levied on petrol from the road users to develop a road development fund called Central Road Fund. CRF was introduced in the year 1929

They gave more stress on long term planning programme, for a period of 20 years (hence called twenty year plan) that is to formulate plans and implement those plans within the next 20 years.

One of the recommendations was the holding of periodic road conferences to discuss about road construction and development. This paved the way for the establishment of a semi-official technical body called Indian Road Congress (IRC) in 1934. Motor vehicle act was brought into effect from 1939.

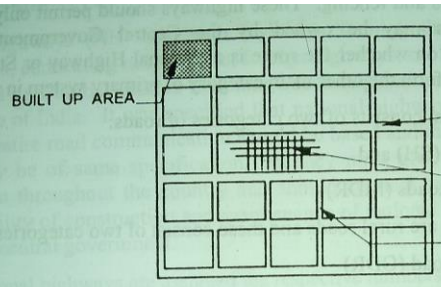
A dedicated research organization should be constituted to carry out research and development work. This resulted in the formation of Central Road Research Institute (CRRI) in 1950.

Road Patterns:

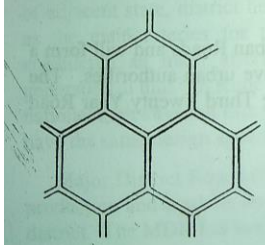
Various road patterns may be classified as

1. Rectangular or block patterns
2. Radial or star and block pattern
3. Radial or star and circular pattern
4. Radial or star and grid pattern
5. Hexagonal pattern
6. Minimum travel pattern

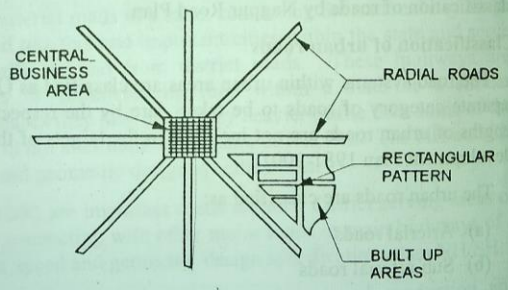
The choice of pattern depends on the locality, layout of different towns, villages, industrial and production centers.



(a) Rectangular or block pattern

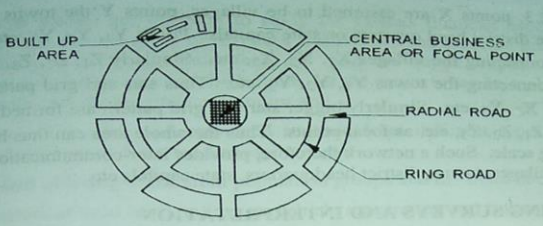


(b) Hexagonal pattern

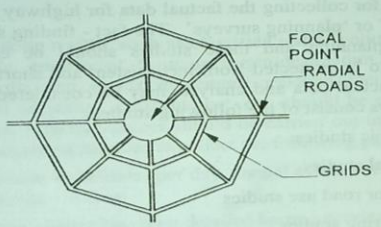


(c) Radial or star and block pattern

Fig. 2.2 Different road patterns (cont....)



(d) Radial or star and circular pattern



(e) Radial or star and grid pattern

Fig. 2.2 Different road patterns

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

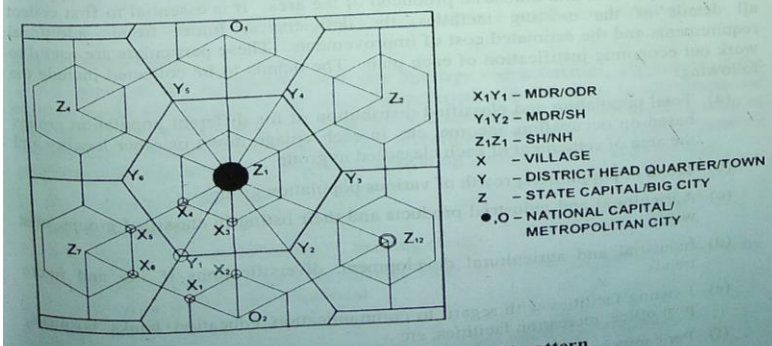


Fig. 2.3 Concept of star and grid pattern

NECESSITY OF HIGHWAY PLANNING

In the present era planning is considered as a pre-requisite before attempting any development programme. Thus highway planning is also a basic need for highway development. Particularly planning is of great importance when the funds available are limited whereas the total requirement is much higher. This is actually the problem in all developing countries like India as the best utilization of available funds has to be made in a systematic and planned way.

The objects of highway planning are briefly given below:

(i) To plan a road net work for efficient and safe traffic operation, but at minimum cost. Here the costs of construction, maintenance and renewal of pavement layers and the vehicle operation costs are to be given due consideration.
(ii) 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?
(iii) 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.
(iv) To plan for future requirements and improvements of roads in view of anticipated developments.
(v) To work out financing system.

Nagpur road plan (1943-1963):

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

A twenty year development programme for the period (1943-1963) was finalized The roads were divided into five classes:

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

The committee planned to construct 2 lakh kms of surfaced road and with overall target of 5.32 lakh kms across the country within 20 years.

They recommended the construction of star and grid pattern of roads throughout the country.

One of the objective was that the road length should be increased so as to give a road density of 16kms per 100 sq.km area. Farthest point in developed and agricultural area is within 8kms of metalled road. In non-agricultural area it is 32kms.

The responsibility of construction and maintenance of national highways was assigned to the central government.

An allowance for agricultural and industrial development during the next 20years was estimated as 15 % and this allowance was to be provided while calculating the road length for both the categories of roads.

The length of rail tracks in the area was also considered in deciding the length of first category road. The length of railway track is directly subtracted from the estimated road length of metalled road.

Target of the plan are achieved by the year 1961. Total length achieved is higher than plan targets but the length of NH and SH achieved were lesser than plan targets.

Total length of NH, SH and MDR in kms is given by a formula

NH+SH+MDR (kms) =

A- Agricultural area, km^2
B- Non Agricultural area, km^2
N - No. of towns and villages with population range 2001-5000
T- No. of towns and villages with population over 5000
D-Development allowance of 15% of road length calculated to be provided for agricultural and industrial development during the next 20 years.
R- existing length of railway track, km

Total length of ODR and VR in kms is given by a formula

ODR+VR (kms) = [0.32V+0.8Q+1.6P+3.2S]+D

V- No. of villages with population 500 or less
Q- No. of villages with population 501 – 1000
P- No. of villages with population 1001-2000
S- No. of villages with population 2001-5000
D- Development allowance of 15% for next 20 years

Bombay road plan 1961-1981:

The length of roads planned under the Nagpur plan was achieved by the end of it, but the road system was deficient in many respects. The changed economic, industrial and agricultural conditions in the country warranted a review of the Nagpur plan. Accordingly a 20-year plan was drafted by the Roads wing of Government of India, which is popularly known as the Bombay plan. The highlights of the plan were:

It was the second 20 year road plan (1961-1981)

The total road length targeted to construct was double the Nagpur plan and was about 10 lakhs.

Rural roads were given specific attention. Scientific methods of construction were proposed for the rural roads. The necessary technical advice to the Panchayaths should be given by State PWD's.

They suggested that the length of the road should be increased so as to give a road density of 32kms/100 sq.km

The construction of 1600 km of expressways was also then included in the plan.

Maximum distance of any place in a developed or agricultural area would be 6.4km from metalled road and 2.4km from any category of roads.

Maximum distance of any place in a semi-developed area would be 12.8 km from metalled road and 4.2 km from any category of roads, similarly maximum distance of any place in an undeveloped area would be 19.2 km from metalled road and 8.0 km from any category of roads.

Every town with population above 2000 in plains and above 1000 in semi-hill areas and above 500 in hilly areas should be connected by a metalled road.

Length of railway track is considered independent of the road system and hence it is not subtracted to get the road length.

The development factor of only 5% is provided for future development and unforeseen factors.

Length of NH (km) =

Length of NH+SH (km) =

Length of NH+SH+MDR (km) =

Length of NH+SH+MDR+ODR (km)
=

Length of NH+SH+MDR+ODR+VR (km)
=

A – Developed and agricultural area, km^2

B – semi-developed area, km^2

C – Undeveloped area, km^2

K – No. of towns with population over 1,00,000

M – No. of towns with population range 1,00,000 – 50,000

N - No. of towns with population range 50,000 – 20,000

P - No. of towns with population range 20,000 – 10,000

Q - No. of towns with population range 10,000 – 5,000

R - No. of towns with population range 5,000 – 2,000

S - No. of towns with population range 2,000 – 1,000

T - No. of towns with population range 1,000 – 500

V - No. of towns with population range below 500

D – development allowance of 5% of total length calculated for further development and other unforeseen factors.

Comparison of Nagpur road plan and Bombay road plan:

S.No	Comparison	Nagpur Plan	Bombay Plan
1	Road Length Formulae	Only two formula (NH+SH+MDR) , (ODR+VR)	Five formula for each type
2	Target Road Density	16km per 100sqm	32km per 100sqm
3	Area	Two types Agricultural and non-agricultural	Three types a. Developed and agricultural b. Semi-developed area c. Undeveloped and uncultivated Area
4	Population Ranges	Maximum population of 5000	Maximum population of 1,00,000
5	Railway Track Length	Railway length is deducted	Railway length is not deducted
6	Development Allowance	15%	5%
7	Expressways	Not considered	1600km of expressways

Lucknow road plan (1981 -2001):

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

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

It aimed at constructing a road length of 12 lakh kilometres by the year 2001 resulting in a road density of 82kms/100 sq.km

The plan has set the target length of NH to be completed by the end of seventh, eighth and ninth five year plan periods.

It aims at improving the transportation facilities in villages, towns etc. such that no part of country is farther than 50 km from NH.

One of the goals contained in the plan was that expressways should be constructed on major traffic corridors to provide speedy travel.

Energy conservation, environmental quality of roads and road safety measures were also given due importance in this plan.

All town and villages with population over 1500 should be connected by MDR and VR with population 1000 to 1500 by ODR.

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 vested 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.

Road Development Plan Vision 2021:

Fourth 20 year developement Plan, 2001 - 2021 should have been formulated and got approved will before the year 2000. However 'Road Development Plan Vision: 2021 was prepared by the Indian Roads Congress at the initiative of the Ministry of road Transport Highways. This vision document has considered the need for overall development of road system in the country. The total target length of primary and secondary road system to be achieved in the country by the year 2020 has been spelt out.

This 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 centres, 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. Considering the importance of this subject, a rural road development plan document was prepared.

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.

Thus against the overall total target road length (all categories of roads) of 27,00,000 km the total length achieved was 3 1,76,000 km.

Primary highway system consisting of 15,766 km of expressways and 80,000 km of national highways.

Secondary road system consisting of 1,60,000 km of state highways and 3,20,000 km of major district roads.

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. Lower population limits were fixed for under developed regions including hills, deserts and tribal areas.

Road Development Plan Vision: 2025' for the 20 - year period of 2005 - 2025 to provide basic access to villages in phases:

Phase - 1, villages with population above 1000.

Phase - 2, villages with population above 500.

Phase -3, villages with population below 500.

Lower population limits were fixed for under developed regions including hills, deserts and tribal areas.

Roads classification:

1. Based on usage

This classification is based on whether the roads can be used during different seasons of the year.

All-weather roads: Those roads which are negotiable during all weathers, except at major river crossings where interruption of traffic is permissible up to a certain extent are called all weather roads.

Fair-weather roads: Roads which are negotiable only during fair weather are called fair weather roads.

2. Based on carriage way

This classification is based on the type of the carriage way or the road pavement.

Paved roads with hard surface: If they are provided with a hard pavement course such roads are called paved roads.(eg: stones, Water bound macadam (WBM), Bituminous macadam (BM), concrete roads)

Unpaved roads: Roads which are not provided with a hard course of atleast a WBM layer they are called unpaved roads. Thus earth and gravel roads come under this category.

3. Based on pavement Surface:

Based on the type of pavement surfacing provided, they are classified as surfaced and unsurfaced roads.

Surfaced roads (BM, concrete): Roads which are provided with a bituminous or cement concreting surface are called surfaced roads.

Unsurfaced roads (soil/gravel): Roads which are not provided with a bituminous or cement concreting surface are called unsurfaced roads.

4. **Other criteria**: Roads may also be classified based on the traffic volume in that road, load transported through that road, or location and function of that road

Traffic volume: Based on the traffic volume, they are classified as heavy, medium and light traffic roads. These terms are relative and so the limits under each class may be expressed as vehicles per day.

Load transported: Based on the load carried by these roads, they can be classified as class I, class II, etc. or class A, class B etc. and the limits may be expressed as tonnes per day.

Location and function: The classification based on location and function should be a more acceptable classification since they may be defined clearly. Classification of roads by Nagpur Road plan is based on the location and function which we had seen earlier.

Nagpur classification

In Nagpur road classification, all roads were classified into five categories as National highways, State highways, Major district roads, other district roads and village roads.

National highways

They 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.

It was recommended by Jayakar committee that the National highways should be the frame on which the entire road communication should be based.

All the national highways are assigned the respective numbers.

For e.g. the highway connecting Delhi-Ambala-Amritsar is denoted as NH-1 (Delhi-Amritsar), where as a bifurcation of this highway beyond Fullundar to Srinagar and Uri is denoted as NH-1_A.

They are constructed and maintained by CPWD.

The total length of National highway in the country is 58,112 Kms, and constitutes about 2% of total road networks of India and carries 40% of total traffic.

State highways

They are the arterial roads of a state, connecting up with the national highways of adjacent states, district head quarters and important cities within the state

They also serve as main arteries to and from district roads.

Total length of all SH in the country is 1,37,119 Kms.

Major district roads

Important roads with in a district serving areas of production and markets , connecting those with each other or with the major highways.

India has a total of 4, 70,000 kms of MDR.

Other district roads

Roads serving rural areas of production and providing them with outlet to market centers or other important roads like MDR or SH.

Village roads

They are roads connecting villages or group of villages with each other or to the nearest road of a higher category like ODR or MDR.

India has 26,50,000 kms of ODR+VR out of the total 33,15,231 kms of all type of roads.

Modern-Lucknow classification

The roads in the country were classified into 3 classes:

Primary roads

Expressways
National highways

Secondary roads

State highways
Major district roads

Tertiary roads

Other district roads
Village roads

Road classification:

The roads can be classified in many ways. The classification based on speed and accessibility is the most generic one. Note that as the accessibility of road increases, the speed reduces. Accordingly, the roads can be classified as follows in the order of increases accessibility and reduced speeds.

Freeways: Freeways are access-controlled divided highways. Most freeways are four lanes, two lanes each direction, but many freeways widen to incorporate more lanes as they enter urban areas. Access is controlled through the use of interchanges, and the type of interchange depends upon the kind of intersecting road way (rural roads, another freeway etc.)

Expressways: They are superior type of highways and are designed for high speeds (120 km/hr is common), high traffic volume and safety. They are generally provided with grade separations at intersections. Parking, loading and unloading of goods and pedestrian traffic is not allowed on expressways.

Highways: They represent the superior type of roads in the country. Highways are of two types - rural highways and urban highways. Rural highways are those passing through rural areas (villages) and urban highways are those passing through large cities and towns, ie. urban areas.

Arterials: It is a general term denoting a street primarily meant for through traffic usually on a continuous route. They are generally divided highways with fully or partially controlled access. Parking, loading and unloading activities are usually restricted and regulated. Pedestrians are allowed to cross only at intersections/designated pedestrian crossings.

Local streets: A local street is the one which is primarily intended for access to residence, business or abutting property. It does not normally carry large volume of traffic and also it allows unrestricted parking and pedestrian movements.

Collector streets: These are streets intended for collecting and distributing traffic to and from local streets and also for providing access to arterial streets. Normally full access is provided on these streets. There are few parking restrictions except during peak hours.

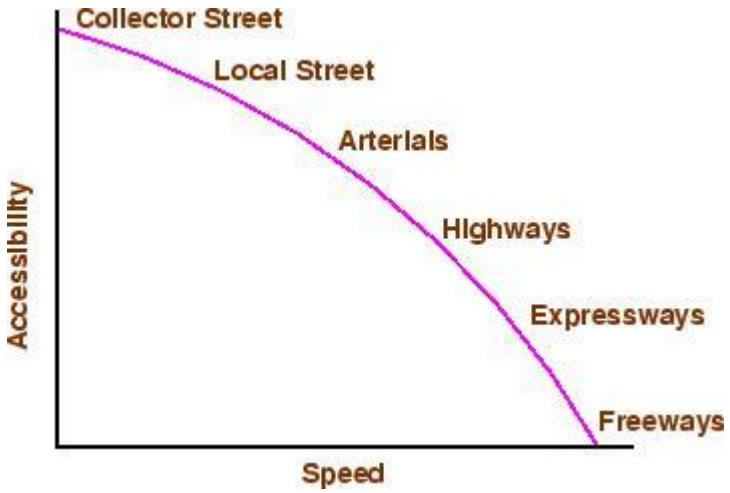


Figure 1: Speed vs accessibility

PLANNING SURVEYS:

Prior to the development of highways planning is required for any engineering works, which is a basic requirement for a new project or for an expansion. In all developing countries like India where, the resources are limited and requirement is high then planning provides better utilization of funds in a system.

Objective 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 datawise priorities for development of each road link based on their utilities.

The planning surveys consist of the following studies:

Economic Studies: This study consists the following details:

Population and its distribution
Trend of population growth
Existing facilities

Per Capita income.

Financial Studies: This study involves collecting the details such as:

Sources of income
Living Standards
Resources from local levels
Factor trends in financial.

Traffic or road use studies: In this details collected are:

Traffic Volume/day, annual or daily traffic peak
flow. Origin and destination studies
Traffic flow patterns
Mass transportation facilities
Accidents, cause and cost analysis

Engineering studies: This involves

Topographic
study Soil details
Location and classification of existing
roads Road life studies

Specific problems in drainage constructions & maintenance.

HIGHWAY ALIGNMENT

Alignment:

The position or the layout of the central line of the highway on the ground is called the alignment. Horizontal alignment includes straight and curved paths. Vertical alignment includes level and gradients.

Requirements:

The requirements of an ideal alignment are: Short, Easy, Safe, Economical.

The alignment between two terminal stations should be short and as far as possible be straight, but due to some practical considerations deviations may be needed.
The alignment should be easy to construct and maintain. It should be easy for the operation of vehicles. So to the maximum extend easy gradients and curves should be provided.
It should be safe both from the construction and operating point of view especially at slopes, embankments, and cutting. It should have safe geometric features.
The alignment should be economical and it can be considered so only when the initial cost, maintenance cost, and operating cost are minimum.

Factors controlling alignment:

We have seen the requirements of an alignment. But it is not always possible to satisfy all these requirements. Hence we have to make a judicial choice considering all the factors.

The various factors that control the alignment are as follows:

1. **Obligatory points**: These are the control points governing the highway alignment. These points are classified into two categories. Points through which it should pass and points through which it should not pass. Some of the examples are:

   Bridge site: The Bridge can be located only where the river has straight and permanent path and also where the abutment and pier can be strongly founded. The road approach to the bridge should not be curved and skew crossing should be avoided as possible. Thus to locate a bridge the highway alignment may be changed.

   Mountain: While the alignment passes through a mountain, the various alternatives are to either construct a tunnel or to go round the hills. The suitability of the alternative depends on factors like topography, site conditions and construction and operation cost.

   Intermediate town: The alignment may be slightly deviated to connect an intermediate town or village nearby.

These were some of the obligatory points through which the alignment should pass. Coming to the second category that is the points through which the alignment should not pass are:

   Religious places: These have been protected by the law from being acquired for any purpose. Therefore, these points should be avoided while aligning.

   Very costly structures: Acquiring such structures means heavy compensation which would result in an increase in initial cost. So the alignment may be deviated not to pass through that point.

   Lakes/ponds etc: The presence of a lake or pond on the alignment path would also necessitate deviation of the alignment.

2. **Traffic:** The alignment should suit the traffic requirements. Based on the origin-destination data of the area, the desire lines should be drawn. The new alignment should be drawn keeping in view the desire lines, traffic flow pattern etc.,
3. **Geometric design:** Geometric design factors such as gradient, radius of curve, sight distance etc., also govern the alignment of the highway. To keep the radius of curve minimum, it may be required to change the alignment. The alignments should be finalized such that the obstructions to visibility do not restrict the minimum requirements of sight distance. The design standards vary with the class of road and the terrain and accordingly the highway should be aligned.
4. **Economy:** The alignment finalized should be economical. All the three costs i.e., construction, maintenance and operating cost should be minimum. The construction cost can be decreased much if it is possible to maintain a balance between cutting and filling. Also try to avoid very high embankments and very deep cuttings as the construction cost will be very higher in these cases.

5. **Other considerations**: various other factors that govern the alignment are drainage considerations, political factors and monotony.

   Drainage

   Political: If a foreign territory comes across a straight alignment, we will have to deviate the alignment around the foreign land.

Monotony: For a flat terrain it is possible to provide a straight alignment, but it will be monotonous for driving. Hence a slight bend may be provided after a few kilometres of straight road to keep the driver alert by breaking the monotony.

Hydrological (rainfall/water table)

Special consideration for hilly areas:

Alignment through hilly areas is slightly different from aligning through a flat terrain. For the purpose of efficient and safe operation of vehicles through a hilly terrain special care should be taken while aligning the highway. Some of the special considerations for highway alignment through a hilly region are discussed below:

Stability of the slopes: for hilly areas, the road should be aligned through the side of the hill that is stable. The common problem with hilly areas is that of landslides. Excessive cutting and filling for road constructions give way to steepening of slopes which in turn will affect the stability.

Hill side drainage: Adequate drainage facility should be provided across the road. Attempts should be made to align the roads in such a way where the number of cross drainage structures required are minimum. This will reduce the construction cost.

Special geometric standards: The geometric standards followed in hilly areas are different from those in flat terrain. The alignment chosen should enable the ruling gradient to be attained in minimum of the length, minimizing steep gradient, hairpin bends and needless rise and fall.

Ineffective rise and fall: Efforts should be made to keep the ineffective rise and excessive fall minimum.

ENGINEERING SURVEYS FOR HIGHWAY LOCATIONS

Before a highway alignment is finalized in highway project, the engineering surveys are to be carried out. The surveys may be completed in four stages. The first three stages consider all possible alternate alignments in Art. 3.1.2. The fourth stage is meant for the detailed survey of the selected alignment.

The stages of the engineering surveys are

(a) Map study (b) Reconnaissance (c) Preliminary surveys (d) Final location and detailed surveys.

Map Study

If the topographic map of the area is available, it is possible to suggest the likely routes of the road. In India, topographic maps are available from the Survey of India, with 15 or 30 meter contour intervals. The main features like rivers, hills valleys, etc. The probable alignment can be located on the map from the following details available on the map.

(a) Alignment avoiding valleys, ponds or lakes

(b) When the road has to cross a row of hills or mountains, possibility of crossing through a mountain pass

(c) Approximate location of bridge site for crossing rivers, avoiding bend of the river, if any

If the contour interval is 15 m and the ruling gradient is fixed as 1 in 20, the minimum road length between two consecutive contours is (15 x 20) 300 m. With the known scale of the map, the various possible alternate routes may be drawn by drawing arcs of 300 m length between the consecutive contour lines.

Reconnaissance

The second stage of engineering surveys for highway alignment is the reconnaissance survey. During the reconnaissance, the engineer visits the site and examines the general characteristics of the area before deciding the most feasible routes for detailed studies. A field survey party may inspect a fairly broad stretch of land along the proposed alternative routes of the map in the field. Only very simple survey instruments are used by the reconnaissance party to collect additional details rapidly, but not accurately. All relevant details which are not available in the map are collected and noted down. Some of the details to be collected during reconnaissance are given below:

(i) valleys, ponds, lakes, marshy land, ridge, hills, permanent structures and other obstructions along the route which are not available in the map

(ii) approximate values of gradient, length of gradients and radius of curves of alternate alignments.

(iii) number and type of cross drainage structures, maximum flood level and natural ground water

(iv) level along the probable routes

Preliminary Survey

The main objectives of the preliminary survey are:

(i) to survey the various alternate alignments proposed after the reconnaissance and to collect all the necessary physical information and details of topography, drainage and soil

(ii) to compare the different proposals in view of the requirements of a good alignment

(iii) to estimate quantity of earth work materials and other construction aspects and to work out the cost of alternate proposals

(iv) to finalise the best alignment from all considerations

The preliminary survey is carried out to collect all the physical information which are necessary in connection with the proposed highway alignment The procedure of the conventional methods of preliminary survey is given in following steps:

(i) primary traverse

(ii) topographical features

(iii) levelling work

(iv) drainage studies and hydrological data

(v) soil survey

(vi) material survey

(vii) traffic studies

Primary traverse

The first step in the preliminary survey is to establish the primary traverse, following the alignment recommended in the reconnaissance. For alternate alignments either secondary traverses or independent primary traverses may be necessary.

Topographic features

After establishing the centre lines of preliminary survey, the topographical features are recorded. All geographical and other man made features along the traverse and for a certain width on either side are surveyed and plotted. The width to be surveyed is generally decided by the survey party, but the absolute minimum width is the land width of the proposed alignment.

Levelling work

Levelling work is also carried out side by side to give the centre line profiles and typical cross sections. Permanent and temporary bench marks should be first established at appropriate locations and the levels should be connected to the GTS datum. The levelling work in the preliminary survey is kept to a minimum just sufficient to obtain the approximate earth work in the alternate alignments.

Drainage studies and hydrological data

Drainage investigations and hydrological data are collected so as to estimate the type, number and approximate size of cross drainage structures. Also the vertical alignment of the highway, particularly the gnde line is decided based on the hydrological and drainage data, such as HFL, ponded water level, depth of water table, amount of surface runoff, etc.

Soil survey

Soil survey is an essential part of the preliminary survey as the suitability of the proposed location is to be finally decided based on the soil survey data. The soil survey conducted at this stage also helps in working out details of earth work, slopes, suitability of materials, subsoil and surface drainage requirements and pavement type and the approximate thickness requirements. All these details are required to make a comparative study of alternate proposals.

Material survey

The survey for naturally occurring materials likes stone aggregates, soft aggregates, etc. and identification of suitable quarries should be made. Also availability of manufactured materials like cement, lime, brick, etc. and their locations may be ascertained.

Traffic survey

Traffic surveys conducted in the region form the basis for deciding the number of traffic lanes and roadway width, pavement design and economic analysis of the highway project. Traffic volume counts of the classified vehicles are to be carried out on all the existing roads in the region, preferably for 24 hours per day for seven days.

Determination of final centre line

After completing the preliminary surveys and conducting the comparative studies of alternative alignments, the final centre line of the road is to be decided in the office before the final location survey. For this, the preliminary survey maps consisting of contour plans, longitudinal profile and cross sections of the alternate alignments should be prepared and carefully studied to decide the best alignment satisfying engineering, aesthetic and economical requirements.

Rapid method using aerial survey and modern technique using GPS

Aerial photographic surveys and photogrammetric methods are very much suited for preliminary surveys, especially when the distance and area to be covered are vast. The survey may be divided into the following steps: Taking aerial photographs of the strips of land to be surveyed with the required longitudinal and lateral overlaps. Vertical photographs are necessary for the preparation of mosaics.

(a) The photographs are examined under stereoscopes and control points are selected for establishing the traverses of the alternate proposals. The control points are located on the maps

(b) Using stereo-pair observations, the spot levels and subsequently contour details may be noted down on the maps

Final Location and Detailed Survey

The alignment finalised at the design office after the preliminary survey is to be first located on the field by establishing the centre line. Next detailed survey should be carried out for collecting the information necessary for the preparation of plans and construction details for the highway project.

Location

The centre line of the road finalised in the drawings is to be transferred on the ground during the location survey. This is done using a transit theodolite and by staking of the centre line. The location of the centre line should follow, as closely as practicable, the alignment finalised after the preliminary surveys. Major and minor control points are established on the ground and centre pegs are driven, checking the geometric design requirements.

Detailed survey

Temporary bench marks are fixed at intervals of about 250 m and at all drainage and under pass structures. Levels along the final centre line should be taken at all staked points. Levelling work is of great importance as the vertical alignment, earth work calculations and drainage details are to be worked out from the level notes. The cross section levels are taken up to the desired width, at intervals of 50 to 100 m in plain terrain, 50 to 75 m in rolling terrain, 50 m in built-up areas and 20 m in hilly terrain. The cross sections may be taken at closer intervals at horizontal curves and where there is abrupt change in cross slopes. All river crossing, valleys etc. should be surveyed in detail up to considerable distances on either side.

DRAWINGS AND REPORT

Drawings

The following drawings are usually prepared in a highway project:

(i) Key map (ii) Index map (iii) Preliminary survey plans (iv) Detailed plan and longitudinal section (v) Detailed cross-section (vi) Land acquisition plans (vii) Drawings of cross drainage and other retaining structures (viii) Drawings of road intersections (ix) Land plan showing quarries etc.

Key map should show the proposed and existing roads, and important places to be connected. The size of the plan generally should not exceed 22 X 20 cm. The scale of the map is chosen suitably depending upon the length of road.

Index map should show the general topography of the area. The details are symbolically represented. The index map should also be of suitable scale, the size being 32 X 20 cm.

Preliminary survey plans showing details of the various alternate alignments and all information's collected should be normally drawn to scale of 10 cm = 1 km to 25 cm =1 km.

Detailed plans show the ground plan with alignment and the boundaries, contours at intervals of 1 to 2 metre in plain country a scale of 1/2400 and in close country, a scale of 1/1200 may be adopted for detailed plans. The size of the drawing may be A-2 size or 60 X 42 cm approximately.

Longitudinal sections should be drawn to the same horizontal scale of the ground as on detailed plan. Vertical scale may be enlarged 10 times of the longitudinal scale. The longitudinal section should show

the details such as datum line, existing ground surface, vertical profile of the proposed road and position of drainage crossings.

Detailed cross sections are generally drawn to natural scale of 1 cm = 2.0 to 2.5 m. Cross section should be drawn every 100 m or where there are abrupt changed in level. In hill roads the cross sections should be drawn at closer intervals. The cross section number, the reduced distances and the area of filling and/or cutting should be shown on cross section drawings.

Land acquisition plans and schedules are usually prepared from the survey drawings for land acquisition details. These plans show all general details such as buildings, wells, nature of gradients and other details required for assessing the values. The scale adopted may be 1 cm = 40 m or less.

Detailed design for cross drainage and masonry structures are usually drawn to scale of 1 cm = 1 m. for details of any complicated portion of the structure enlarged scales up to 8 cm = 1 m. or up to half full size may be employed. However the size of drawing should not exceed the standard size. Cross sections of streams should be to a scale of not less than 1 cm = 10 m.

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

Land plans for quarries. Where quarries for construction materials are to be acquired for new projects, separate land plans should be prepared. The size of these maps and scaled may be similar to those suggested under land acquisition.