Highway Alignment and Engineering Survey (4 hrs)

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2.1.1 Introduction:

The position of the center line of the highway in the ground is called highway alignment. Highway alignment includes horizontal alignment and vertical alignment. The projection of highway alignment in horizontal plane is called horizontal alignment and the projection in vertical plane is known as vertical alignment. Alignment must be selected in such a way that the overall cost during construction, operation and maintenance is minimum. Road design outputs are in the form of following drawings:

Plan: Includes centre line, structures, Right of Way (ROW), carriage way, shoulders, side drain.

Longitudinal Profile: Soil Type, Depth of cut, Height of Fill, Side drain (Information on from which chainage to which chainage), Direction of flow in the drain.

Cross section: Ground Level, Formation Level, Super elevation, Area of Cutting and Area of filling thus computation of the volume and then cost estimation can be done.

2.1.2 Requirements of Highway Alignment:

The ideal alignment must have the following requirements:

- Safe (S)
- Easy (E)
- Short (S)
- Economical (E)
- Comfort (C)

The requirements can be memorized as **SESEC.**

Safe: The alignment need to be safe during construction, operation and maintenance especially at slopes, embankments and cutting.

Easy: The construction materials if present at the place of construction makes the construction easier. Similarly, it should be easy during the operation of vehicles with easy gradients and curves.

Short: The distance between the initial and final point need to be short so as to reduce the construction cost.

Economical: The alignment should be economical during construction, operation, and maintenance. However, if the construction turned out to be economical, the gradient may not be easy which in turns increases the cost of operation and maintenance. Similarly, if the vehicle operation is taken under consideration and is made economical, the construction cost becomes higher as the gradient and curves need to be easy.

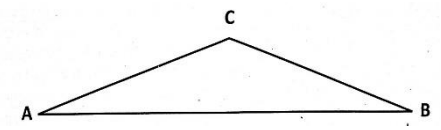
Comfort: The alignment should be fixed such that it provides comfort to the drivers and the passengers.

2.1.3 Factors Controlling Highway Alignment:

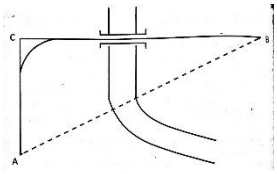
- **Governmental Requirement:** As the road project needs a large investment, the government should be clear about the requirement of the road (when, what, how and why to construct).

- **Obligatory Points:** Obligatory points determine the highway alignment. They are further divided into positive obligatory points and negative obligatory points.
  Positive Obligatory Points: These are those points through which the alignment should pass.

  - **Existing Road:** The alignment should be fixed such that the newly constructed road should link to the existing road. It reduces the cost of construction.
  - **Intermediate Town:** If there is the possibility of a straight road between point A and B and there lies the intermediate town at C as shown, then the road need to link the intermediate town reducing the change in highway alignment.



  - **Bridge site/Existing Bridge:** The road linking with the bridge must not be curved and to include the bridge in the road portion, the highway alignment may be changed.



  - **Mountain:** When the road has to cross a row of hills, mountain pass may be the suitable alternative.

  Negative Obligatory Points: These are those points through which the alignment should not pass.

  - Valleys, ponds, and marshy land need to be avoided.
  - Religious places are linked up with the human sentiment so cannot be destroyed for fixing the road alignment.
  - Costly structures present in the way of alignment should be considered and the road alignment should be fixed such that it won't destroy those costly structures as the value of compensation for such structures will be more.
  - Conservation areas and restricted zones.
  - Densely populated area.
  - The road should not be within the boundary of the country.

- **Traffic (Type, amount and flow pattern):**
  The alignment should be according to the traffic amount and flow pattern. The number of lanes can be determined as:
  Number of lanes = Traffic Volume / Traffic Capacity.
- **Geological Condition:**
  Geologically stable hill slope must be considered while selecting the highway alignment.
- **Geometric Design:**
  Various factors regarding geometric design as the radius of curve, sight distance, gradient determines the highway alignment.
- **Availability of construction materials and labor:**
  The construction works become easier and economical when the construction materials are near the place of highway alignment.
- **Economy:**
  The construction, operation, and maintenance work should be economical. So, highway alignment is selected keeping these things in mind.

- **Other Considerations:**
  Drainage: The alignment needs to be fixed such that the number of cross drainage structures are less.
  Political: Alignment need to be within the allocated territory.
  Monotony: Setting the straight alignment leads to monotonous driving. So a small bend is provided to make the driver aware and alert. The roads are designed as forgiving roads.

Special Consideration in Hill Roads:

- **Stability:** The road should be aligned with the hill side that is stable. Excessive cutting and filling may effect on their stability.
- **Drainage:** Adequate drainage facility need to be provided across the road and the number of cross drainage structures need to be less during construction.
- **Geometric Standards:** Geometric design parameters also effect on the construction of roads. Minimizing steep gradient, hairpin bends and needless rise and fall.
- **Resisting Length:** The ineffective rise and excessive fall should be minimum.

2.2 Engineering Survey and its stages:

- Map Study
- Reconnaissance
- Preliminary Survey
- Final Location and Detailed Survey

2.2.1 Structure of Route Selection Process:

Sequential Structure of Route Location Process

Region → Bands (8-16km) → Corridors (3-10km) → Route Strips (1-1.5km) → Alignments (30-50m)

The beginning and the end point is selected and the region is defined. The region is further studied in search of broad bands which are 8-16km wide. From these broad bands, the corridor is studied then the route strips and possible alignments are found out.

2.2.2 Engineering Surveys: Map Survey, Reconnaissance, Preliminary Survey and Detailed Surveys:

Map Study:

The study of the topographical map is done to find out the possible routes of the road. Following information are obtained from the map study:

- Alignment avoiding valley, ponds, lakes.
- When the road has to cross a row of hills, mountain pass may be the suitable alternative.
- Approximate location of the bridge site.

Reconnaissance Survey:

Simple Survey Instruments are used in the reconnaissance procedure.
Following are the information obtained from the reconnaissance survey:

- Valley, pond, lakes and other features that were not present in the topographical map.
- A number of cross drainage structures, High Flood Level (HFL), Natural Ground Level.
- Values of the gradient, the length of gradients and radius of the circular curve.
- Soil type along the routes from field identification tests and observation of the geological features.
- Sources of construction materials.

Preliminary Survey:

Sophisticated Survey Instruments are used during the preliminary survey.
Objective of the Preliminary Survey are listed below:

- To collect necessary physical information and details of topography, drainage, and soil.
- To compare different proposal in view of the requirement of good alignment.
- To estimate the quantity of earthwork.
- To finalize the best alignment.

Methods of Preliminary Survey:

- Conventional Approach
- Modern Rapid Approach

Conventional Method:

The procedure for the conventional approach are listed below:

- **Traverse:** The traverse is run from the starting point to the end point by setting out various control points. Both primary traverse and secondary traverse may need to be run.
- **Levelling work:** The levelling work is carried out along the centre line or the proposed road. The levelling work is used to estimate the volume of the earthwork. Both L-section and X-section are carried out.
- **Topographical features:** All geographical and man-made features are survey and plotted which are along the traverse and for a certain width on either side.

- **Drainage Studies and Hydrological data:** The number of cross drainage structures are estimated during the preliminary survey.
- **Soil Survey:** The soil survey is conducted in working out details of earthwork, slope, and stability of materials, subsoil and surface drainage requirements and the type of the pavement requirements.
- **Material Survey:** The location of construction materials need to be known.
- **Traffic Survey:** Survey regarding the number of lanes, roadway width, and pavement design need to be done.
- **Determination of final centre line:** After completion of all the above mention steps and calculating the amount of earthwork, the final centre line is determined.

Modern rapid approach:

The procedure of the Modern rapid approach are listed below as:

- Taking aerial photographs with required lateral and longitudinal overlaps.
- These photographs are then examined under stereoscopes and control points are selected for the establishment of the traverse.
- The spot levels and contour lines may be obtained from the stereo – pair observations.
- Photointerpretation method is used to grab information on the geological features, soil conditions, drainage requirement, etc.

Final Location and Detailed Survey:

Location: The centre line of the road which is finalized in the preliminary survey is then located in the field by establishing the centre line. Major and minor control points are then established on the ground and the central pegs are driven, checking the geometric design criteria. If necessary, the modification of the final location can be altered.

Detailed Survey:

- Temporary Bench Marks (TBM) are fixed at all under pass structures and drainage structures.
- Levels along the final centre line should be taken with great importance as these data are required for vertical alignment, earth work calculation, and drainage details.
- A detailed survey is carried out to enable drawing the soil profile up to the depth of 1.5-3m below the Ground Line and twice the height of the finished embankment in the case of the high embankment.
- The data during the detailed survey should be elaborated and completed for the preparation of the plans, designing, and estimation of the project.

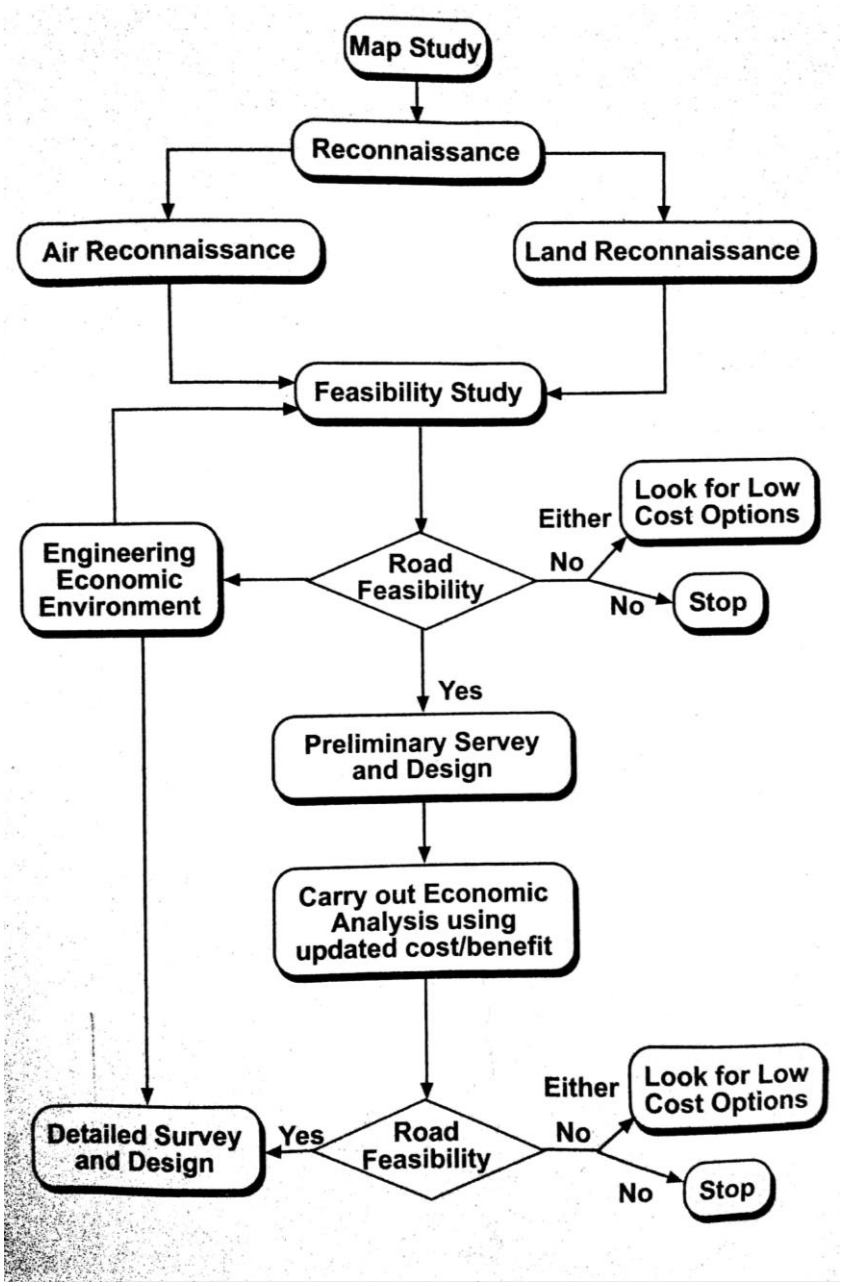


Fig: Sequence of Engineering Survey for Highway Alignment

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Nepal Road Standard 2070

Nepal Rural Road Standard 2071

IIT Lecture Notes