# Highway Alignment and Engineering Survey

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Transportation Engineering I

## 2. Highway Alignment and Engineering Survey

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# Highway Alignment and Engineering Survey

## 2.1 Highway Alignment



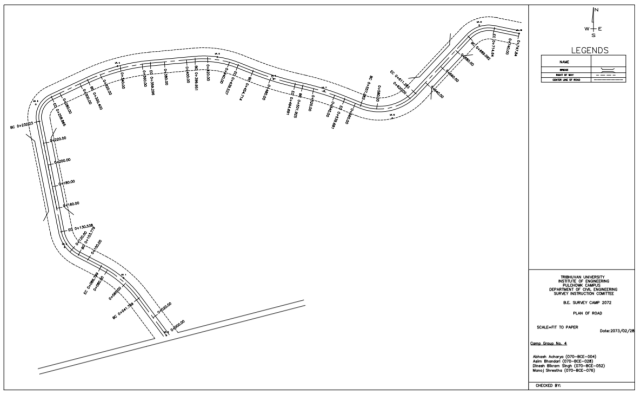
## 2.1.1 Introduction

- The position of the center line of the highway in the ground is called highway alignment.
- Includes horizontal alignment and vertical alignment.
  - Projection of highway alignment in horizontal plane is called horizontal alignment.
  - Projection of highway alignment in vertical plane is called vertical alignment.
- Alignment must be selected in such a way that the overall cost during construction, operation and maintenance is minimum.

## 2.1.1 Introduction

**Road Design Outputs**

- Plan: Includes centre line, structures, Right of Way (ROW), Carriage Way, Shoulders, Side Drain

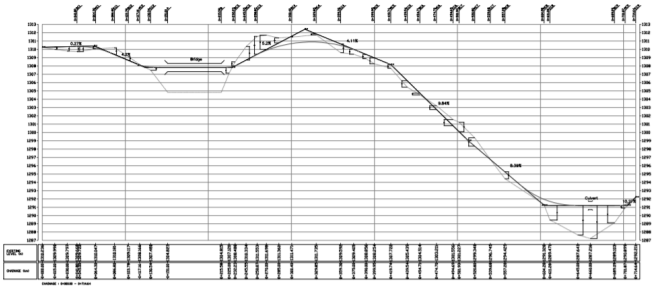





## 2.1.1 Introduction

**Road Design Outputs**

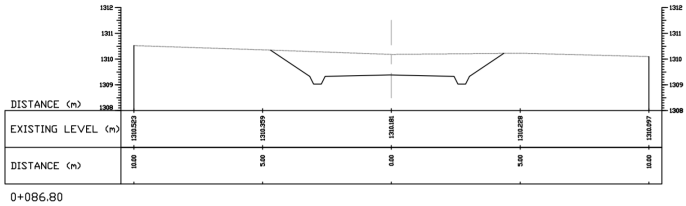
- Longitudinal Profile: Soil Type, Depth of Cut, Height of Fill, Side Drain (Information on from which chainage to which chainage), Direction of flow in the drain



## 2.1.1 Introduction

### Road Design Outputs

- Cross Section: Ground Level, Formation Level, Super elevation, Area of Cutting and Area of filling.






## 2.1.1 Introduction

### Road Design Outputs

- 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.

## 2.1.2 Requirements of Highway Alignment

**Requirements of Highway Alignment**

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

**SESE**

- **Safe:** 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. It should be easy during the operation of vehicles with easy gradients and curves.
- **Short:** The distance between the initial and final point needs to be short so as to reduce the construction cost.
- **Economical:** Should be economical during construction, operation and maintenance. However, if the construction turned out to be economical, gradient may not be easy which 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

**Factors controlling Highway Alignment**

- Governmental Requirements
- Obligatory Points
- Traffic (Type, amount and flow pattern)
- Geological condition
- Geometric design
- Availability of construction materials and labor
- Economy
- **Drainage consideration**
- **Political**
- **Monotony**

**Special consideration in Hill Roads**

- Stability
- Drainage
- Geometric standards
- Resisting Length

## 2.1.3 Factors controlling Highway Alignment

### Factors Controlling Highway Alignment

- **Governmental Requirements**
  - 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)
- **Traffic (Type, amount and flow pattern):**
  - Alignment should be according to traffic volume and flow pattern. Eg. Straight path for fast moving vehicles.
  - Number of lanes = Traffic Volume / Traffic Capacity
- **Geological Condition:**
  - Geologically stable hill slope must be considered.
- **Geometric Design:**
  - Various factors regarding geometric design as radius of curve, sight distance, gradient determines the highway alignment.



## 2.1.3 Factors controlling Highway Alignment

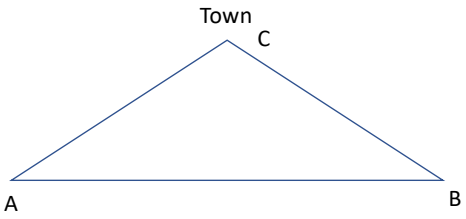
### Factors Controlling Highway Alignment

- **Availability of construction materials and labor:**
  - The construction works become easier and economical when the construction materials are available near the place of highway alignment.
- **Economy**
  - The construction, operation and maintenance work should be economical.

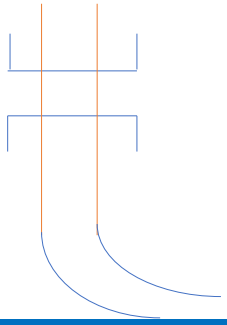
## 2.1.3 Factors controlling Highway Alignment

**Factors Controlling Highway Alignment**

- Obligatory Points
  - Positive obligatory points
  - Negative obligatory points




- Positive obligatory points
  - Points through which the alignment should pass.
    - Existing road
    - Intermediate town
    - Bridge site/Existing bridge
    - Mountain pass





## 2.1.3 Factors controlling Highway Alignment

**Factors Controlling Highway Alignment**

- Obligatory Points
  - Positive obligatory points
  - Negative obligatory points

- Negative obligatory points
  - Points through alignment should not pass
    - Valleys, ponds, marshy lands
    - Religious places
    - Costly structures
    - Conservation areas and restricted zones
    - Densely populated area

## 2.1.3 Factors controlling Highway Alignment

**Factors Controlling Highway Alignment**

- **Obligatory Points**
  - **Positive Obligatory Points**
    - Points through which 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 needs 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.



## 2.1.3 Factors controlling Highway Alignment

**Factors Controlling Highway Alignment**

- **Obligatory Points**
  - **Negative Obligatory Points**
    - Points through which alignment should not pass
      - Valleys, ponds, and marshy land need to be avoided.
      - Religious places are linked up with the human settlement, so cannot be destroyed for fixing 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 high.
      - Conservation areas and restricted zones.
      - Densely populated area.

## 2.1.3 Factors controlling Highway Alignment

### Factors Controlling Highway Alignment

- **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.



## 2.1.3 Factors controlling Highway Alignment

### Factors Controlling Highway Alignment

- **Special Consideration in Hill Roads**
  - **Stability:** Road should be aligned with the hill side that is stable. Excessive cutting and filling may affect their stability.
  - **Drainage:** Adequate drainage facilities 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 affect on the construction of roads. Minimizing steep gradient, hairpin bends and needless rise and falls.
  - **Resisting Length:** Ineffective rise and excessive fall should be minimum.

The roads are designed as forgiving roads.

## 2.2 Engineering Survey and its Stages





### Structure of Route Selection Process/Structure of Highway Location

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

- Beginning and end points are fixed, and the region is defined.
  - Region shall include all possible routes.
- Region is further studied in search of broad bands.
  - Number of bands are selected within region; width depend on the nature of road and terrain.
- Corridors are studied within these bands.
- Routes are searched within corridor within which alignments are selected.

## 2.2.2 Engineering Survey: Map Study, Reconnaissance, Preliminary and Detailed Survey

### Engineering Survey and its stages

- **Map Study/Desk Study**
  - Involves an examination of a relatively large area between terminal points for determining broad corridors.
  - Use of available maps (Topographical, geological, agricultural soil maps, natural resource maps)
  - Information about obligatory points
  - Topography, geology, climate and traffic volumes
  - Environmental, including types of wildlife, location of recreational, historic and archeological sites, effects on environment
  - Economic, including unit costs for construction



## 2.2.2 Engineering Survey: Map Study, Reconnaissance, Preliminary and Detailed Survey

### Engineering Survey and its stages

- **Reconnaissance (Recci)**
  - Examines the general character of land between the terminal stations in the field.
  - Use of simple survey instruments like compass, abney level.
  - Involves inspection of each band.
    - Terrain and soil conditions (gradient/soil type)
    - Valley, ponds, lakes, marshy land, ridge, hills, permanent structures, etc.
    - Crossing of other transportation facilities as rivers, railroads and highways
    - HFL, Natural ground level
    - Sources of construction materials
    - Likely surface and sub-surface drainage problems.
    - Affected population and effects (land acquisition and relocation, pollution, damage to religious sites)
  - Directness of roads are considered, and control points are established.
  - One or more routes will be recommended.
  - If more than one routes passed the recci, the best would be chosen in preliminary survey.

## 2.2.2 Engineering Survey: Map Study, Reconnaissance, Preliminary and Detailed Survey

### Engineering Survey and its stages

- **Preliminary Survey**
  - Used to evaluate the economic and environmental feasibility of the alternative routes.
  - Consists of running an accurate traverse line along the routes already recommended by recci survey in order to obtain sufficient data for final location.
  - Objectives
    - To collect necessary data (topography, drainage, soil, etc.) on alternate alignments.
    - To estimate quantity of earthwork, material, etc. of different alternatives and find cost estimate.
    - To compare alternate alignments and select the best alignment from all considerations.



## 2.2.2 Engineering Survey: Map Study, Reconnaissance, Preliminary and Detailed Survey

### Engineering Survey and its stages

- **Preliminary Survey**
  - **Economic evaluation**
    - Carried out to determine the future effect of investing the resources to construct the highway
  - **Environmental evaluation**
    - Construction of highway at a given location may result in significant changes in one or more variables, which in turn may offset the equilibrium and result in significant adverse effects on the environment

## 2.2.2 Engineering Survey: Map Study, Reconnaissance, Preliminary and Detailed Survey

**Engineering Survey and its stages**

- **Preliminary Survey**
  - Methods – Conventional Approach/Modern Rapid Approach
    - Conventional
      - Taking measurements, collecting topographical and other data
      - Carrying out soil survey using equipment as theodolites, levels, total stations

        Traverse → Levelling work → Topographical features → Drainage studies → Soil survey → Material survey → Traffic survey → Determination of final center line
    - Modern rapid approach → Photogrammetry, Geographic Information System (GIS)



## 2.2.2 Engineering Survey: Map Study, Reconnaissance, Preliminary and Detailed Survey

**Engineering Survey and its stages**

- **Preliminary Survey**
  - Conventional Approach
    - **Traverse**: The traverse is run from starting point to end point by setting out various control points. Both primary traverse and secondary traverse may need to be run.
    - **Levelling work:** Levelling work is carried out along the centre line or the proposed road. Levelling work is used to estimate the volume of earthwork. Both L-section and X-section levelling are carried out.
    - **Topographical features:** All geographical and man-made features are surveyed 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.

## 2.2.2 Engineering Survey: Map Study, Reconnaissance, Preliminary and Detailed Survey

**Engineering Survey and its stages**

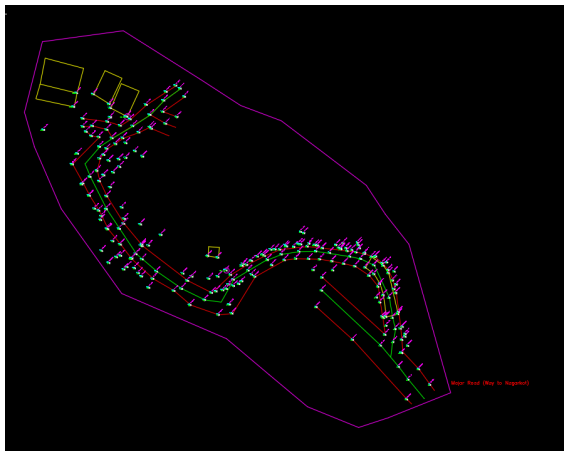
- **Preliminary Survey**
  - Conventional Approach
    - **Soil Survey:** The soil survey is conducted in working out the details of earthwork, slope and stability of materials, subsoil and surface drainage requirements and the type of the pavement requirements.
    - **Material Survey:** The location of construction materials need to be known.
    - **Traffic Survey:** Survey regarding number of lanes, roadway width, and pavement deign need to be done.
    - **Determination of final centre line:** After completion of all the above-mentioned steps and calculating the amount of earthwork, the final centre line is determined. It includes economic evaluation of cost and benefits.



## 2.2.2 Engineering Survey: Map Study, Reconnaissance, Preliminary and Detailed Survey

**Engineering Survey and its stages**

- **Preliminary Survey**
  - Conventional Approach



## 2.2.2 Engineering Survey: Map Study, Reconnaissance, Preliminary and Detailed Survey

**Engineering Survey and its stages**

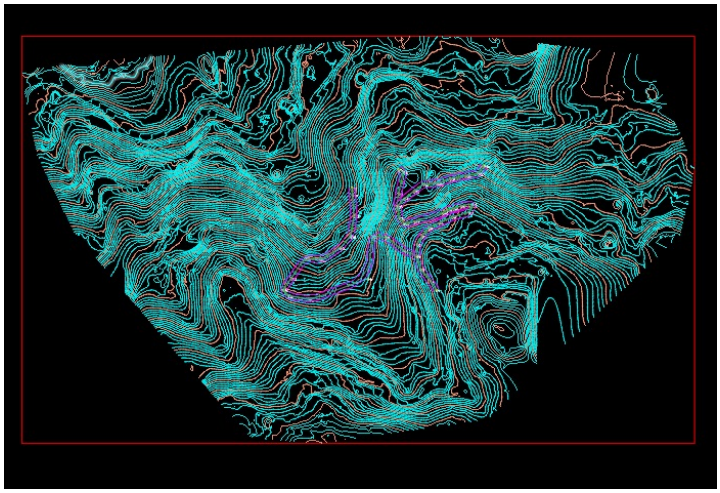
- **Preliminary Survey**
  - Modern Rapid Approach
    - Taking aerial photographs with required lateral and longitudinal overlaps.
    - Photographs are then examined, and control points are selected for the establishment of traverse.
    - Spot levels and contour lines may be obtained from the stereo-pair observations.
    - Photo interpretation method is used to grab information on the geological features, soil conditions, drainage requirements, etc.



## 2.2.2 Engineering Survey: Map Study, Reconnaissance, Preliminary and Detailed Survey

**Engineering Survey and its stages**

- **Preliminary Survey**
  - Modern Rapid Approach



## 2.2.2 Engineering Survey: Map Study, Reconnaissance, Preliminary and Detailed Survey

**Engineering Survey and its stages**

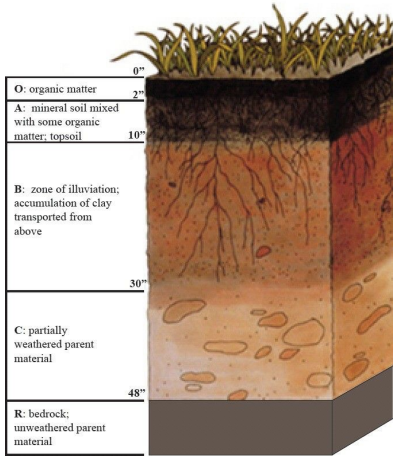
- **Final location survey**
  - **Purposes**
    - To fix the center line of the selected alignment
    - To collect additional data for the design and preparation of working drawings
  - Locating the center line
    - The center line of the road which is finalized in the preliminary survey
    - The road is then located in the field by establishing center line
    - Stations established at 30m intervals



## 2.2.2 Engineering Survey: Map Study, Reconnaissance, Preliminary and Detailed Survey

**Engineering Survey and its stages**

- **Final location survey**
  - Detailed Survey:
    - Detailed layout of the selected route.
    - Horizontal and vertical alignments are determined, and the positions of structures and drainage channels are located.
    - TBM fixation
    - Levels along the final center line. Includes profile and cross-section leveling.
    - Drawing the soil profile upto 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.



## 2.2.2 Engineering Survey: Map Study, Reconnaissance, Preliminary and Detailed Survey

**Engineering Survey and its stages**

- **Preparation of Detailed Drawings and Reports**
  - Site plan
  - Detailed plan and profile
  - Cross sections
  - Typical roadway sections
  - Mass Haul Diagram
  - Construction details of bridges, culverts and other structures



## 2.2.2 Engineering Survey: Map Study, Reconnaissance, Preliminary and Detailed Survey

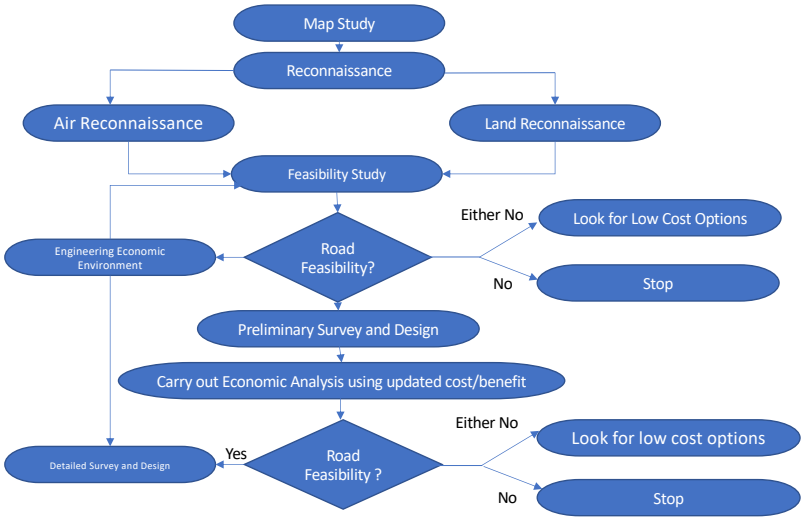



Fig: Sequence of Engineering Survey for Highway Alignment

**Thank You!**

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