

ENGINEERING SURVEYS FOR HIGHWAY ALIGNMENT

Stages of Engineering Surveys

Before a highway alignment is finalised in a new highway project, engineering surveys are to be carried out. These engineering surveys may be completed in the following four stages:

- a) Map Study
- b) Reconnaissance Survey
- c) Preliminary Surveys
- d) Final Location and Detailed Surveys

Map Study

It is possible to suggest the likely routes of the roads if the topographic map of the areas is available. In India, topographic maps are available from the Survey of India, with 15 or 30 metre contour intervals. The main features like rivers, hills valleys, etc. are also shown on these maps.

The probable alignment can be located on the map from the following details available on the map.

- Alignment avoiding valleys, ponds or lakes
- When the road has to cross a row of hills or mountains, possibility of crossing through a mountain pass.
- Approximate location of bridge site for crossing rivers, avoiding bend of the river, if any
- When a road is to be connected between two stations, one of the top and the other on the foot of the hill, then alternate routes can be suggested keeping in view the design ruling gradient and the maximum permissible gradient

Thus, from the map study alternate routes can be suggested. It may also be possible from map study to drop a certain route in view of any unavoidable obstructions or undesirable ground and map study gives a rough guidance of the routes to be further surveyed in the field.

Reconnaissance Survey

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, 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

- a) Valleys, ponds, lakes, marshy land, ridge, hills, permanent structures and other obstructions along the route which are not available in the map.

- b) Approximate values of gradient, length of gradients and radius of curves of alternate alignments.
- c) Number and type of cross drainage structures, maximum flood level and natural ground water level along the probable routes.
- d) Soil type along the routes from field identification tests and observation of geological features.
- e) Sources of construction materials, water and location of stone quarries
- f) When the road passes through hilly or mountainous terrain, additional data regarding the geological formation, type of rocks, dip of strata, seepage flow etc. may be observed so as to decide the stable and unstable sides of the hill for highway alignment

A rapid reconnaissance of the area, especially when it is vast and the terrain is difficult and it may be done by aerial survey. From the details collected during the survey the alignment proposed may be altered or even changes completed.

Preliminary Survey

The main objectives of the preliminary survey are

- To survey the various alternate alignment proposed after the reconnaissance and to collect all the necessary physical information and details of topography, drainage and soil
- To compare the different proposals in view of the requirements of a good alignment.
- To estimate quantity of earthwork materials and other construction aspects and to work out the cost of alternate proposals.

The preliminary survey may be carried out by of following methods

- a) Conventional approach, in which a survey party carries out surveys using the required field equipment, taking measurements, collecting topographical and other data and carrying out soil survey
- b) Rapid approach, by aerial survey taking the required aerial photographs and by photogrammetric methods and photo-interpretation techniques for obtaining the necessary topographic and other maps including details of soil and geology

Modern techniques by use of Global Positioning System (GPS)

The procedure of the conventional methods of preliminary survey is given in following steps:

- a) Primary Traverse
- b) Topographical Features
- c) Levelling Work
- d) Drainage Studies and Hydrological Data

- e) Soil Survey
- f) Material Survey
- g) Traffic Studies Primary Traverse

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. As these traverses are open traverses and adjustment of errors is not possible later, the angles should be very accurately measured using a precision theodolite.

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. To draw contours of the strip of land to be surveyed, cross section levels should be taken at suitable intervals, generally 100 to 200 m in plain terrain, up to 50 m in rolling terrain and up to 30 m in hilly terrain.

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 grade 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. A detailed soil survey is not necessary. Post-hole auger or any other suitable types of hand augers may be used depending

on the soil type to collect the soil sample up to a depth of 1 to 3 metre below the likely finished road level or the existing ground level, whichever is lower. When the road is expected to be constructed over an embankment, the depth of exploration should extend up to twice the height of embankment from the ground level. During the soil exploration if the ground water table is struck, the depth from the ground surface is also noted. The types of soils encountered along the route up to the depth under consideration are marked on the soil profile either symbolically or by suitable colour coding.

Material Survey

The survey for naturally occurring materials like 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. Origin and destination surveys are very useful for deciding the alignment of the roads. This study may be carried out on a suitable sample of vehicle users or drivers. In addition, the required traffic data may also be collected so that the traffic forecast could be made for 10 to 20 year periods.

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. After selecting the final alignment, the grade lines are drawn and the geometric elements of the horizontal and vertical alignments of the road are designed.

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
- c) Photo-interpretation methods are used to assess the geological features, soil conditions, drainage requirements etc.

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. However, modifications in the final location may be made in the field, if found essential. The centre linestakes are driven at suitable intervals, say at 50 metre intervals in plain and rolling terrains and at 20 metre in hilly terrain.

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.
- All topographical details are noted down and also plotted using conventional signs. Adequate hydrological details are also collected and recorded.
- A detailed soil survey is carried out to enable drawing of the soil profile. The depth up to

which soil sampling is to be done may be 1.5 to 3.0 m below the ground line or finished grade line of the road whichever is lower. However, in case of high embankments, the depth should be up to twice the height of the finished embankment. The spacing of auger borings very much depends upon the soil type and its variations.

- CBR value of soils along the alignment may be determined for designing the pavement.
- The data during the detailed survey should be elaborate and complete for preparing detailed plans, design and estimates of the project.

