CHAPTER 3. HIGHWAY ROUTE SURVEYS AND LOCATION

3.1 General

To determine the geometric features of road design, the following surveys must be conducted after the necessity of the road is decided.

Type of surveys and investigations

A variety of survey and investigations have to be carried out by Road engineers and multidiscipline persons.

A. Transport Planning Surveys

- ✓ Traffic Surveys
- ✓ Highway inventories
- ✓ Pavement Deterioration Study
- ✓ Accident study

B. Alignment and Route location surveys

- ✓ Desk study
- ✓ Reconnaissance survey
- ✓ Preliminary Survey
- ✓ Final location survey

C. Drainage Studies

- ✓ Surface run- off : hydrologic and hydraulic
- ✓ Subsurface drainage: Ground water & Seepage
- ✓ Cross –drainage: location and waterway area required for the cross-drainage structures.

D. Soil Survey

- ✓ Desk study
- ✓ Site Reconnaissance
- ✓ Determining the complete soil profile through appropriate soil exploration techniques; obtaining both disturbed and undisturbed samples and testing of samples

E. Pavement Design investigation

- ✓ Soil property and strength ,Material Survey

3.2 Highway Alignment and Route Location Survey

Once the necessity of the highway is assessed, the next process is deciding the alignment and route location. 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 curves and gradients. Alignment decision is important because a bad alignment will enhance the construction, maintenance and vehicle operating costs. Once an alignment is fixed and constructed, it is not easy to change it due to increase in cost of adjoining land and construction of costly structures by the roadside.

In general, the aim of alignment selection process is to find a location for the new road that will result in the lowest total construction, land, traffic and environmental costs.

Before an attempt can be made at selecting a physical location for a highway improvement, data must be available regarding traffic desires and needs the planning intentions within the area to be traversed, and estimates or the future physical characteristics of the highway itself: Location surveys involving geologic and photogrammetric skills provide the basic information for structural design, as well as the economic analysis that have a considerable influence on the final location of the highway.

Steps in Route Selection:

- ✓ Know the termini points of the scheme.

- ✓ From the study of a map of the area, identify and locate; National parks, Any ancient relics, castles and the likes, Existence of monasteries, Mining sites, Existing transport facilities, Other public facilities (electricity, water), Location of construction materials
- ✓ Conduct preliminary and reconnaissance surveys and collect information on pertinent details of topography, climate, soil, vegetation, and any other factors.
- ✓ Based on the information collected in the previous two steps select a corridor.
- ✓ Identify a number of possible centerlines within the corridor.
- ✓ Make a preliminary design for the possible alternative alignments and plot on a base map.
- ✓ Examine each of the alternative alignment with respect to grades, volume of earthwork, drainage, crossing structures, etc. to select the best alternative route.
- ✓ Make final design and location of the selected best alternative route

3.3 Guidelines for Alignment and Route Selection

There are certain guidelines that must be borne in mind in selecting the alignment and locating the route. They are:

- The route of the highway should be so selected that it can handle the traffic most efficiently and serve the inhabited localities.
- The alignment should be economical and it can be considered so only when the initial cost, maintenance cost, and operating cost are minimum.
- 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.

- 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 gradients should not be steeper and curvature not sharper than the limiting values specified for different types of terrain or standards. Excess of either or both may result

in economy of initial cost, but will involve extremely high operation costs, time costs and accident costs.

- The location should minimize the use of agricultural land. If a road already exists, it may be advisable to make use of the land already available to the maximum extent.
- The location should involve the least impact on the environment.
- Obstructions such as cemeteries, places of worship, archaeological and historical monuments should be steered through.
- Proximity to schools, playgrounds, very costly structures, lakes/ponds and hospitals should be avoided.
- Interference with utility services like electric overhead transmission lines, water supply mains, sewers, pipelines, etc should be avoided as far as possible.
- Frequent crossing of railway lines should be avoided.
- Locate the highway close to sources of embankment materials and pavement materials.
- Avoid marshy and low-lying land areas having poor drainage.
- Avoid areas liable to flooding.
- Steep terrain should be avoided as much as possible.
- Deep cutting and costly tunnels should be avoided as far as possible.
- Avoid areas subjected to subsidence due to mining operations.
- When the alignment has to cross major rivers, the crossing point should be fixed carefully.

Summary:

- Topography, slope stability, flood hazard and Erosion are likely to be the most significant in the choice of alignment and design of cross section.

- Geology, Geomorphology and hydrology are key factors in the design, construction and maintenance of road in Ethiopia. Road geometry, earth works, retaining structures and drainage measures must be designed in such a manner as to cause the least impact on the stability of the surrounding slops and natural drainage systems.

- To aid in the decision making process, a classical conceptual approach has tended to be developed with regard to gathering information about the areas being evaluated. Generally, these can be divided into:

1. Reconnaissance survey
2. Preliminary location survey
3. Final location survey

3.4 Reconnaissance survey

The purpose of the reconnaissance survey is to evaluate the feasibility of one or more corridor routes for a highway between specific points that may be many kilometers away. Mostly a desk study, good reconnaissance survey can be the greatest single money-saving phase in the construction of a new road. Hence the engineer should make ample provision in both time and finance for this stage of highway location study.

The first step in the reconnaissance survey is the location and acquisition of all maps and data relating to the area, as well as the most suitable air photographs usually called desk study and the second step of reconnaissance survey is visiting the site collecting additional data usually called as field study.

Desk study

The first step in route survey and investigation is to study all available information in the office, Comprises a review of published and unpublished information concerning the Physical, economical and environmental characteristics of the study area .

Some of the data that may be required:

- ✓ Published literatures: Road construction and maintenance case histories and geological, economical and environmental reviews.
- ✓ Topographic Map
- ✓ Geological maps, Agricultural or land development map, soil map and other natural resource maps.
- ✓ Aerial Photography if possible satellite imagery (eg. Landsat/MSS and Radar images.

Available maps

REFERENCE:	SOURCE
- Index Map of Coverage Scales	Ethiopian Mapping Authority
- Atlas of Ethiopia	Ethiopian Mapping Authority
- Topographic Maps scale 1:250,000	Ethiopian Mapping Authority
- Topographic Maps scale 1:50,000	Ethiopian Mapping Authority
- Aerial photographs, approximate scale 1:50,000	Ethiopian Mapping Authority
- Geological Map of Ethiopia, scale 1:2,000,000	Geological Survey of Ethiopia
- Hydrological Map of Ethiopia, scale 1:2,000,000	Ministry of Agriculture
- Land Use and Land Cover Map, scale 1:1,000,000	Ministry of Agriculture
- Hydro geological Map, Scale 1:1,000, 000	Ethiopian Institute of Geological

- All possible routes shall be located and examined on maps, satellite and air photos.

Field study

It involves inspection of each band (identified during the desk study) to determine the most feasible corridor route based on some basic criteria. A survey party inspects a fairly broad stretch of land along the proposed routes identified on the map during the 1st phase and collects all relevant details not available on the map.

A team consisting of the following personal or Engineers should make a site inspection visit (ERA)

- ✓ Highway Engineer
- ✓ Soil & material (pavement) Engineer
- ✓ Hydrologist
- ✓ Chief Surveyor
- ✓ Bridge/Structural Engineer

- ✓ Environmentalist / Sociologist ,and
- ✓ Local Administrative Personnel

The following information or data should be determined or collected during the Reconnaissance survey

1. Terrain classification
2. Bridging requirements (number ,length)
3. Existing means of communication (mule path, 4WD...)
4. Right-of way available ,bringing out constraints on account of built-up areas, monuments and other structures
5. Slope stability and the location of pre-existing land slides
6. Geology of the area (Geological structures, rock strength...)
7. Percentage of rock in excavation
8. Construction Material sources, presence and distribution.
9. Water source
10. Location of existing or proposed utilities along the alignment
11. Soil type and depth
12. Land use and value of land (Agricultural, built-up, forest)
13. Necessity of by passes for town and villages
14. Likely foundation conditions for major structures.
15. Slope drainage and ground water condition
16. Soil erosion and soil erodibility.
17. Drainage Stability and location of shifting channels and bank erosion.

18. Flood levels and river training/ protection requirement

19. Ecology or environmental factors (land use impact)

20. The possibility of using any existing alignment.

21. Verify the accuracy of all collected data during the desk study.

Upon completion of the reconnaissance survey, the engineer should be at least in a position to design the more detailed geotechnical investigations which are likely to follow, and should also have sufficient information available which, when taken in combination with the social, ecology, traffic, economic, and political inputs, will enable the selection of one or more apparently feasible corridor routes. If the reconnaissance survey has been very thorough, and the necessary data are readily available, it may be possible immediately to carry out the necessary economic and environmental comparisons to aid in the determination of the best corridor route.

The results of these studies are presented in a reconnaissance report. In its barest essentials, this report should state the service and geometric criteria to be satisfied by the project, describe the preferred route(s), and present tentative estimates of the cost.

3.5 Preliminary Location Survey

The preliminary survey is a large-scale study of one or more feasible corridor routes. It results in a paper location and alignment that defines the line for the subsequent final location survey. This paper location and alignment should show enough ties to existing topography to permit a location party to peg the centerline. In many cases field details for final design may also be obtained economically during the preliminary survey phase. It consists of running an accurate traverse line along the routes already recommended as a result of reconnaissance survey in order to obtain sufficient data for final location.

- ✓ Establishing primary Traverse following the line recommended in the reconnaissance survey
- ✓ Record all topographical features
- ✓ Levelling work: to determine the Centre Line, Profile & Typical Cross-sections (just sufficient to approximate earthwork)

- ✓ Hydrological Data: to estimate type, number, & size of cross-drainage structures, and the grade line is decided based on the hydrological and drainage data
- ✓ Soil Survey: the suitability of proposed alignment is to be finally decided based on the soil survey data. The soil survey at this stage helps to work out details of earthwork, slopes, suitability of materials, sub-soil and surface drainage requirements, pavement type and approximate thickness requirements

The preliminary survey is made for the purpose of collecting the additional physical information that may affect the location of the highway within a given corridor area, the shape of the ground, any potential ground subsidence problems, the limits of the catchment areas, the positions and invert levels of streams and ditches, and the positions of trees, banks and hedges, bridges, culverts, existing roads, power lines and pipe lines, houses and monuments are determined and noted. These are then translated into maps, profiles and (frequently) cross sections that can assist the engineer in the determination of preliminary grades and alignments and the preparation of cost estimates for alternative centerlines.

Two approaches are available for preliminary survey mapping: aerial surveys and ground surveys, either separately or in various combinations.

The ground survey method is best used in the situation where then corridor is closely defined, narrow right-of-way are contemplated, and the problems of man-made culture are clear. Ground surveys, beginning with a traverse baseline, will probably furnish necessary data quite economically. Additional operations that can be quite easily included are the profile levels and cross-sections, and the ties to land lines and cultural objects.

The aerial survey is likely to be more suitable and economical in the following instances:

- ✓ Where the reconnaissance was unable to approximate closely the final alignment?
- ✓ Where a wide right-of-way is necessitated?
- ✓ Where it is desired to prevent the premature or erroneous disclosure of the details of probable location (preventing any land speculation or the premature awakening of local public concerns).

In general, the objectives of preliminary surveys are

- ✓ Survey and collect necessary data (topography, drainage, soil, etc.) on alternate corridor routes.
    - Establishing primary Traverse following the line recommended in the reconnaissance survey.
    - Record all topographical features.
    - Levelling work: to determine the Centre Line, Profile & Typical Cross-sections (just sufficient to approximate earthwork)
    - Hydrological Data: to estimate type, number, & size of cross-drainage structures, and the grade line is decided based on the hydrological and drainage data.
    - Soil Survey: the suitability of proposed alignment is to be finally decided based on the soil survey data. The soil survey at this stage helps to work out details of earthwork, slopes, suitability of materials, sub-soil and surface drainage requirements, pavement type and approximate thickness requirements
- ✓ To estimate quantity of earthwork, material, … of different corridor routes
- ✓ Compare alternate corridor routes.
- ✓ Finalize the best corridor routes from all consideration

3.6 Final Location Survey

This survey, much of which is very often carried out as part of the preliminary survey serves the dual purpose to fix the centre line of the selected alignment and collect additional data for the design and preparation of working drawings. If extensive data is collected earlier, the survey work here might be limited.

Steps in Final Location Survey

- ✓ Pegging the centre line: usually done at stations established at 30m intervals with reference to preliminary traverse/ base line (if used earlier) or a control survey (if aerial survey was used).

- ✓ Centre-line Levelling: at the stations and at intermediate points between stations where there is a significant change in the slope to obtain the representative profile of the ground
- ✓ Cross-section Levelling: at each station and at points with significant change in ground slope
- ✓ Intersecting Roads: the directions of the centre line of all intersecting roads, profiles, and cross-sections for some distance on both sides.
- ✓ Ditches and Streams: horizontal alignment, profile, and cross section levelling of the banks of the stream.

The data, after the necessary investigation and final location survey, is sent to the design office to be used for geometric design, pavement design, and design of drainage and other structures, preparation of drawings, reports, and specifications

A complete set of drawings for a road design include:

- Site plan of proposed alignment
- Detailed Plan & Profile
- Cross-sections for Earth work
- Typical Roadway sections at selected locations (e.g. junctions)
- A mass-haul diagram
- Construction details of structures like bridges, culverts,