HIGHWAY SURVEYS AND LOCATION

Highway Surveys and Location: Introduction

- **S**electing the location of a proposed highway is an important initial step in its design.
- The decision to select a particular location is usually based on:
  - Topography
  - Soil characteristics
  - Environmental factors such as noise and air pollution
  - Economic factors

- The data required for the decision process are usually obtained from different types of surveys, depending on the factors being considered.
- Most engineering consultants and state agencies presently involved in highway locations use computerized techniques to process the vast amounts of data that are generally handled in the decision process.
- These techniques include:
  - ***remote sensing*** – uses aerial photographs for the preparation of maps
  - ***computer graphics*** – uses a combination of the analysis of computer-generated data with a display on a computer monitor.

- Principles of Highway Location

PRINCIPLES OF HIGHWAY LOCATION

- The basic principle for locating highways is that roadway elements such as curvature and grade must blend with each other to produce a system that provides for the easy flow of traffic at the design capacity, while meeting design criteria and safety standards.
- The highway should also cause a minimal disruption to historic and archeological sites and to other land-use activities.
- Environmental impact studies are therefore required in most cases before a highway location is finally agreed upon.

Phases of highway location process

- The highway location process involves **four phases**:

1. Office study of existing information
2. Reconnaissance survey
3. Preliminary location survey
4. Final location survey

1. Office study of existing information

- The first phase in any highway location study is the examination of all available data of the area in which the road is to be constructed.
- This phase is usually carried out in the office prior to any field or photogrammetric investigation.
- All of the available data are collected and examined.
- These data can be obtained from existing engineering reports, maps, aerial photographs, and charts, which are usually available at one or more of the state's departments of transportation, agriculture, geology, hydrology, and mining.

Key x-tic areas for which data should be obtained

The type and amount of data collected and examined depend on the type of highway being considered, but in general, data should be obtained on the following characteristics of the area:

- **Engineering:** topography, geology, climate, and traffic volumes
- **Social and demographic:** land use and zoning patterns
- **Environmental:** types of wildlife; location of recreational, historic, and archeological sites; and the possible effects of air, noise, and water pollution
- **Economic:** unit costs for construction and the trend of agricultural, commercial, and industrial activities

1. Office study of existing information

- Preliminary analysis of the data obtained will indicate whether any of the specific sites should be excluded from further consideration because of one or more of the above characteristics.
- ***For example***: If it is found that a site of historic and archeological importance is located within an area being considered for possible route location, it may be immediately decided that any route that traverses that site should be excluded from further consideration.
- At the completion of this phase of the study, the engineer will be able to select general areas through which the highway can traverse.

2. Reconnaissance Survey

- The object of this phase of the study is to identify several feasible routes, each within a band of a limited width of a few hundred feet.
- When rural roads are being considered, there is often little information available on maps or photographs, and therefore aerial photography is widely used to obtain the required information.

2. Reconnaissance Survey

- Feasible routes are identified by a stereoscopic examination of the aerial photographs, taking into consideration factors such as:
  - Terrain and soil conditions
  - Serviceability of route to industrial and population areas
  - Crossing of other transportation facilities, such as rivers, railroads, and highways
  - Directness of route

2. Reconnaissance Survey

- Control points between the two endpoints are determined for each feasible route.
- ***For example:*** a unique bridge site with no alternative may be taken as a primary control point. The feasible routes identified are then plotted on photographic base maps.

3. Preliminary Location Survey

- During this phase of the study, the positions of the feasible routes are set as closely as possible by establishing all the control points and determining preliminary vertical and horizontal alignments for each.
- Preliminary alignments are used to evaluate:
  - Economic feasibility
  - Environmental feasibility

Alternative routes

Economic evaluation

- Economic evaluation of each alternative route is carried out to determine the future effect of investing the resources necessary to construct the highway.
- Factors usually taken into consideration include:
  - road user costs
  - construction costs
  - maintenance costs
  - road user benefits
  - any disbenefits e.g. adverse impacts due to dislocation of families, businesses, and so forth.

- The results obtained from the economic evaluation of the feasible routes provide valuable information to the decision maker.
- ***For example***: these results will provide information on the economic resources that will be gained or lost if a particular location is selected.
- This information is also used to aid the policy maker in determining whether the highway should be built, and if so, what type of highway it should be.

Environmental Evaluation

- Construction of a highway at any location will have a significant impact on its surroundings.
- A highway is therefore an integral part of the local environment and must be considered as such.
- This environment includes plant, animal, and human communities and encompasses social, physical, natural, and man-made variables.
- These variables are interrelated in a manner that maintains equilibrium and sustains the lifestyle of the different communities.

- The construction of a 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.
- This may lead to a reduction of the quality of life of the animals and/or human communities.
- It is therefore essential that the environmental impact of any alignment selected be fully evaluated.

In general, the requirements call for the submission of environmental impact statements for many projects. These statements should include:

- A detailed description of alternatives
- The probable environmental impact, including the assessment of positive and negative effects
- An analysis of short-term impact as differentiated from long-term impact
- Any secondary effects, which may be in the form of changes in the patterns of social and economic activities
- Probable adverse environmental effects that cannot be avoided if the project is constructed
- Any irreversible and irretrievable resources that have been committed

- In cases where an environmental impact study is required, it is conducted at this stage to determine the environmental impact of each alternative route.
- Such a study will determine the negative and/or positive effects the highway facility will have on the environment.
- ***For example:*** the construction of a freeway at grade through an urban area may result in an unacceptable noise level for the residents of the area (negative impact), or the highway facility may be located so that it provides better access to jobs and recreation centers (positive impact).

- Public hearings are also held at this stage to provide an opportunity for constituents to give their views on the positive and negative impacts of the proposed alternatives.
- The best alternative, based on all the factors considered, is then selected as the preliminary alignment of the highway.

4. Final Location Survey

- The final location survey is a detailed layout of the selected route.
- The horizontal and vertical alignments are determined, and the positions of structures and drainage channels are located.
- The method used is to set out the points of intersections (PI) of the straight portions of the highway and fit a suitable horizontal curve between these.
- This is usually a trial-and-error process until, in the designer's opinion, the best alignment is obtained, taking both engineering and aesthetic factors into consideration.

- The availability of computer-based techniques has significantly enhanced this process since a proposed highway can be displayed on a monitor, enabling the designer to have a driver's eye view of both the horizontal and vertical alignments of the road.

- The designer can therefore change either or both alignments until the best alignment is achieved.

- Detailed design of the vertical and horizontal alignments is then carried out to obtain both the deflection angles for horizontal curves and the cuts or fills for vertical curves and straight sections of the highway

Location of Highways in Urban Areas

- Urban areas usually present complex conditions that must be considered in the highway location process.
- In addition to factors discussed under office study and reconnaissance survey, other factors that significantly influence the location of highways in urban areas include:
  - ***Connection to local streets***
  - ***Right-of-way acquisition***
  - ***Coordination of the highway system with other transportation systems***
  - ***Adequate provisions for pedestrians***

Principles of Bridge Location

- The basic principle for locating highway bridges is that the highway location should determine the bridge location, not the reverse.
- When the bridge is located first, in most cases the resulting highway alignment is not the best.
- In some cases, this will result in skewed bridges, which are more expensive to construct, or in locations where foundation problems exist.
- When serious problems of this nature occur, all factors such as highway alignments, construction costs of the bridge deck and its foundation, and construction costs of bridge approaches should be considered in order to determine a compromise route alignment that will give a suitable bridge site.
- This will include completing the transportation planning process and the economic evaluation of the benefits and costs

- A detailed report should be prepared for the bridge site selected to determine whether there are any factors that make the site unacceptable.
- This report should include:
  - accurate data on soil stratification
  - the engineering properties of each soil stratum at the location
  - the crushing strength of bedrock
  - water levels in the channel or waterway

- When the waterway to be crossed requires a major bridge structure,
  - HOWEVER it is necessary to first identify a narrow section of the waterway with suitable foundation conditions for the location of the bridge
  - THEN determine acceptable highway alignments that cross the waterway at that section.
- This will significantly reduce the cost of bridge construction in many situations.

HIGHWAY SURVEY METHODS

- Highway surveys usually involve measuring and computing horizontal and vertical angles, vertical heights (elevations), and horizontal distances.
- The surveys are then used to prepare **base maps** with **contour lines** and **longitudinal cross-sections**.
- Highway surveying techniques have been revolutionized due to the rapid development of electronic equipment and computers.
- Surveying techniques can be grouped into three general categories:
  - ***Ground surveys***
  - ***Remote sensing***
  - ***Computer graphics***

1. Ground Surveys

- The Total Station
- Electronic Distance-Measuring Devices (EDM)
- The Level
- Measuring Tapes

Digital Survey Advancements

- Survey Data Collectors
- Multilayered Information
- Global Positioning System Surveys

2. Remote Sensing

- Remote sensing is the measurement of distances and elevations by using devices located above the earth, such as airplanes (aerial photogrammetry) or orbiting satellites using Global Positioning Satellite systems (GPS).

3. Computer Graphics

- Computer graphics, when used for highway location, is usually the combination of photogrammetry and computer techniques.
- With the use of mapping software, line styles, and feature tables, objects and photographic features can be recorded digitally and stored in a computer file.
- A typical workstation is controlled by system software that covers four main areas of design work:
- ***Preparatory work (project setup)***
- ***Photo orientations and aerotriangulation***
- ***Data transfer***
- ***Plotting and storage***