TRANPORTATION FACILITY DESIGN PROCESS

Design Process

The design process for a transportation facility or transportation systems is a mixture of technical, legal, and political elements.

In general, *planning* refers to the more general and abstract parts of the process and *design* to the more detailed and concrete; both involve use of rational process to decide how to use the available resources to achieve goals.

The overall design process is a coordinated process of information gathering, analysis and decision-making.

In most of the cases, it is open-ended (there is no one right answer, although some answers may be better than others in terms of particular goals), and iterative, so that various alternatives are proposed and evaluated before the final decision.

Design Process

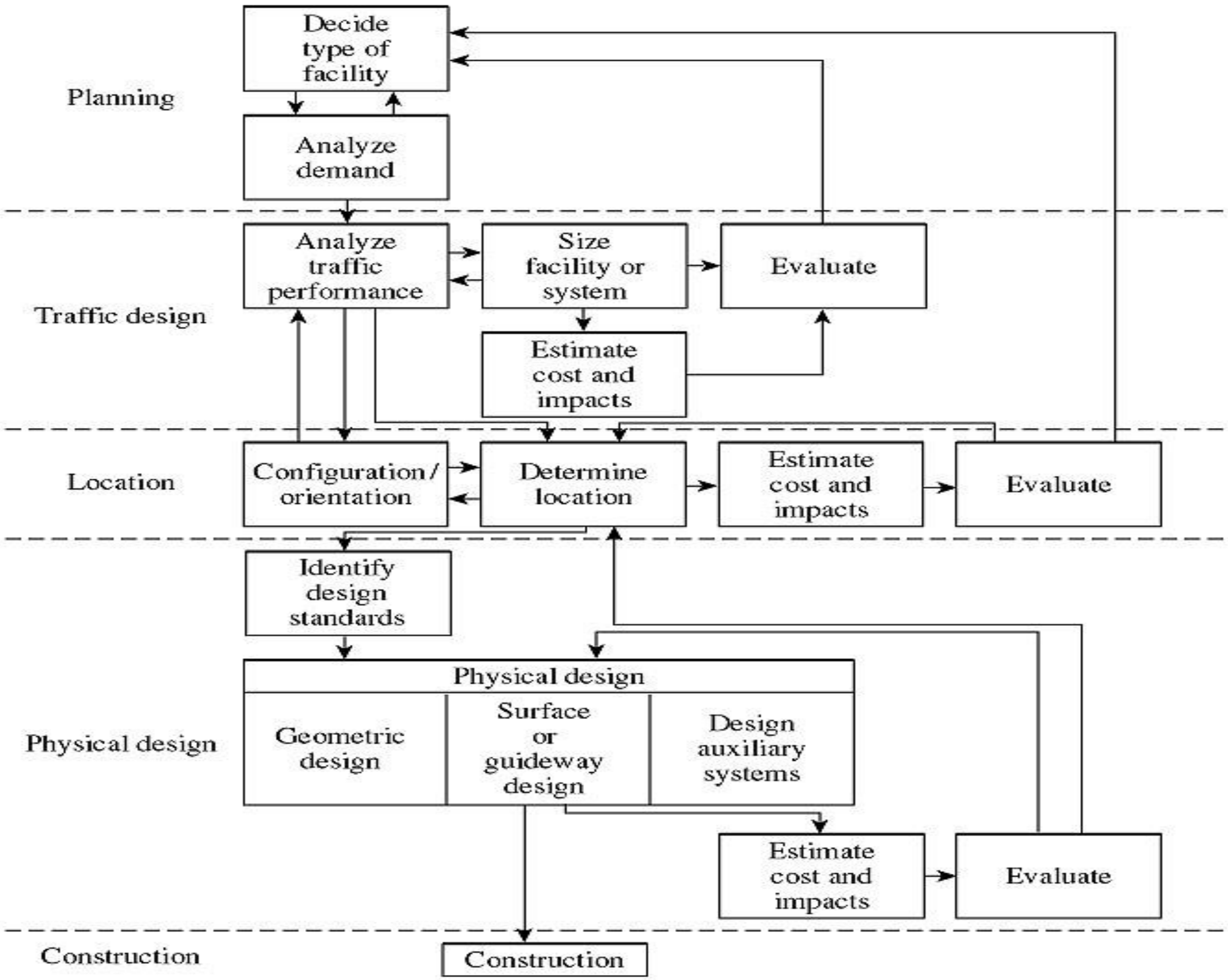

Figure 3.1 The Design Process (Banks, Fig. 3.1, p.48)

Design Process

The basic phases are labeled as

- planning,
- traffic design,
- location
- physical design,
- and resulting in ultimately construction of the facility.

These phases overlap to some extent, and some of them may repeat many times.

Specific steps in transportation design process:

1. Deciding generally what sort of system or facility is needed:
2. Demand analysis
3. Traffic Performance Analysis
4. Size
5. Determination of the location
6. Determination of configuration and/or orientation of the facility or system
7. Identification of physical design standards
8. Geometric Design
9. Design of Auxiliary Systems
10. Design of surface or guideway
11. Estimation of construction costs and project impacts
12. Evaluation of design

Design Codes

Responsibility for the establishment of design standards varies, depending on the type of facility and country.

In the USA, the design standards for the state highways are established by the state departments of transportations, which usually are based on recommended standards of the American Association of State Highway and Transportation Officials (AASHTO).

The principal source of recommended standards for the geometric design is the AASHTO Policy on Geometric Design of Highways and Streets (often referred to as the “Green Book”).

In addition, Federal Highway Administration (FHWA) has established the minimum design standards for the Interstate System.

Design Codes

In Turkey General Directorate of Highways **(*Karayolları Genel Müdürlüğü*)** establishes the design standards for highways.

Municipality roads are under the responsibility of municipalities and there are standards established by Turkish Standards Institute **(*Türk Standartları Enstitüsü*)** for certain design features, such as intersections, biking lanes, pedestrian walkways, etc. but there is no legal system to force municipalities to follow these standards.

Design Documents

In most cases, the agency owning the facility will contract out its construction. In order to solicit bids from potential contractors or to enter into contract, it is necessary to document the design, allowable materials, and required construction techniques in detail. Bid documents are often spoken of as including ***plans***, ***specifications***, and ***estimations*****.**

Plans refers to drawings, usually accompanied by notes of various aspects or components of the design

Specifications are written instructions detailing how the facility is to be constructed.

Estimates include cost estimates for various parts of the project and are used to evaluate the acceptability of bids and financial feasibility of the project.

Design Documents

Construction plans for linear transportation projects (highways, railways, runways, etc.) consist of four basic elements:

1) The ***plan view*** (or simply the "plan"): the drawing of the facility as it would look to an observer directly above it (See Figure 2)
2) The ***profile*** : It has elevation as its vertical axis, and horizontal distance, as measured along the centerline of the facility (or other recognized reference line) as its horizontal axis (See Figure 3)
3) The ***geometric cross sections*****:** It has elevation as its vertical axis and horizontal distance, measured perpendicular to the centerline, as its horizontal axis (See Figure 4).
4) The ***superelevation diagram***: For curved facilities (in highways or railways), it consists of a graph with roadway or railway cross-slope (vertical axis) versus horizontal distance (horizontal axis).

Design Documents

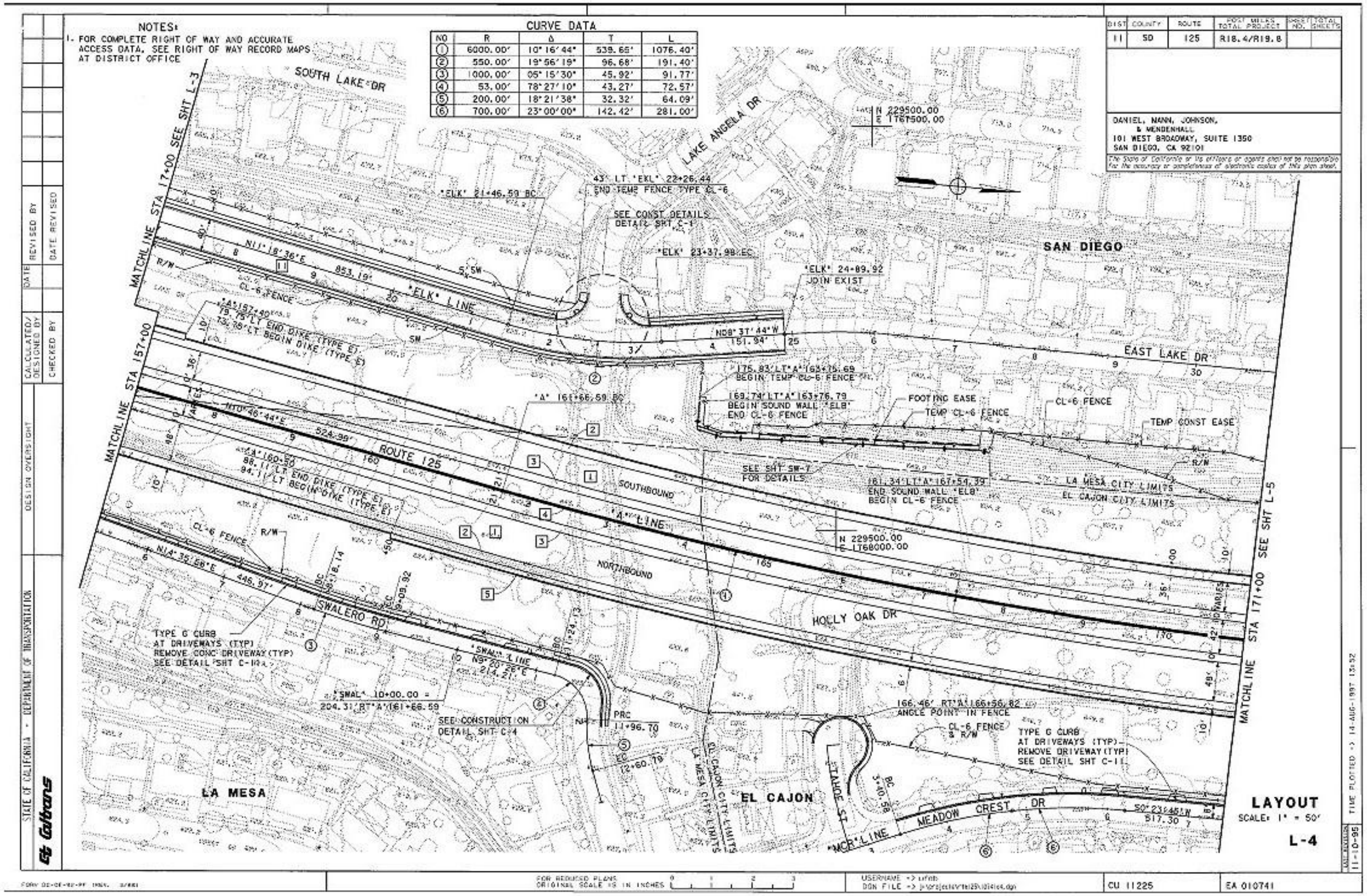

Figure 3.2 Highway plan view (Banks, Fig. 3.3, p. 58)

Design Documents

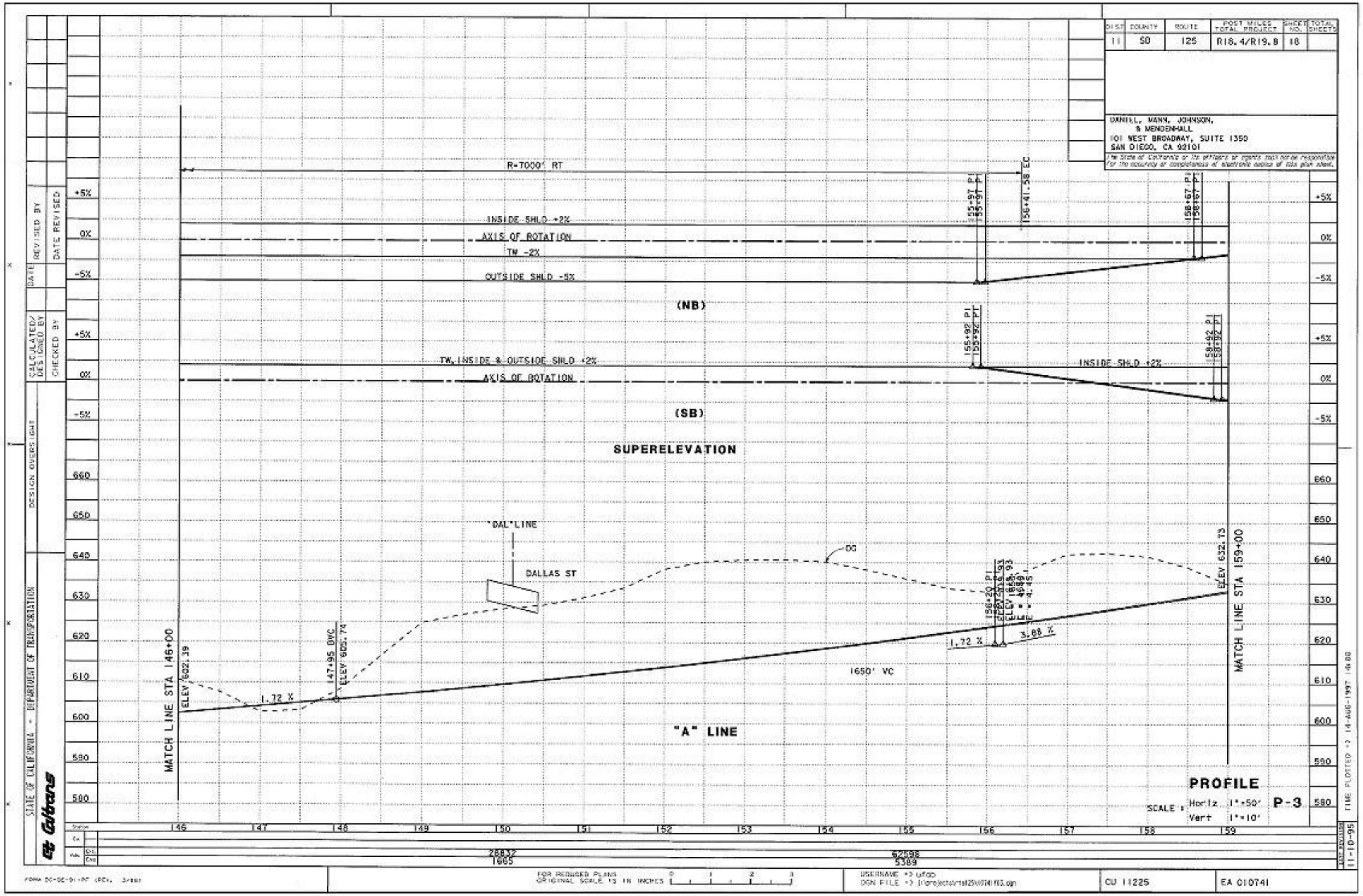

Figure 3.3 Highway profile and superelevation (Banks, Figure 3.4, p. 59)

Design Documents

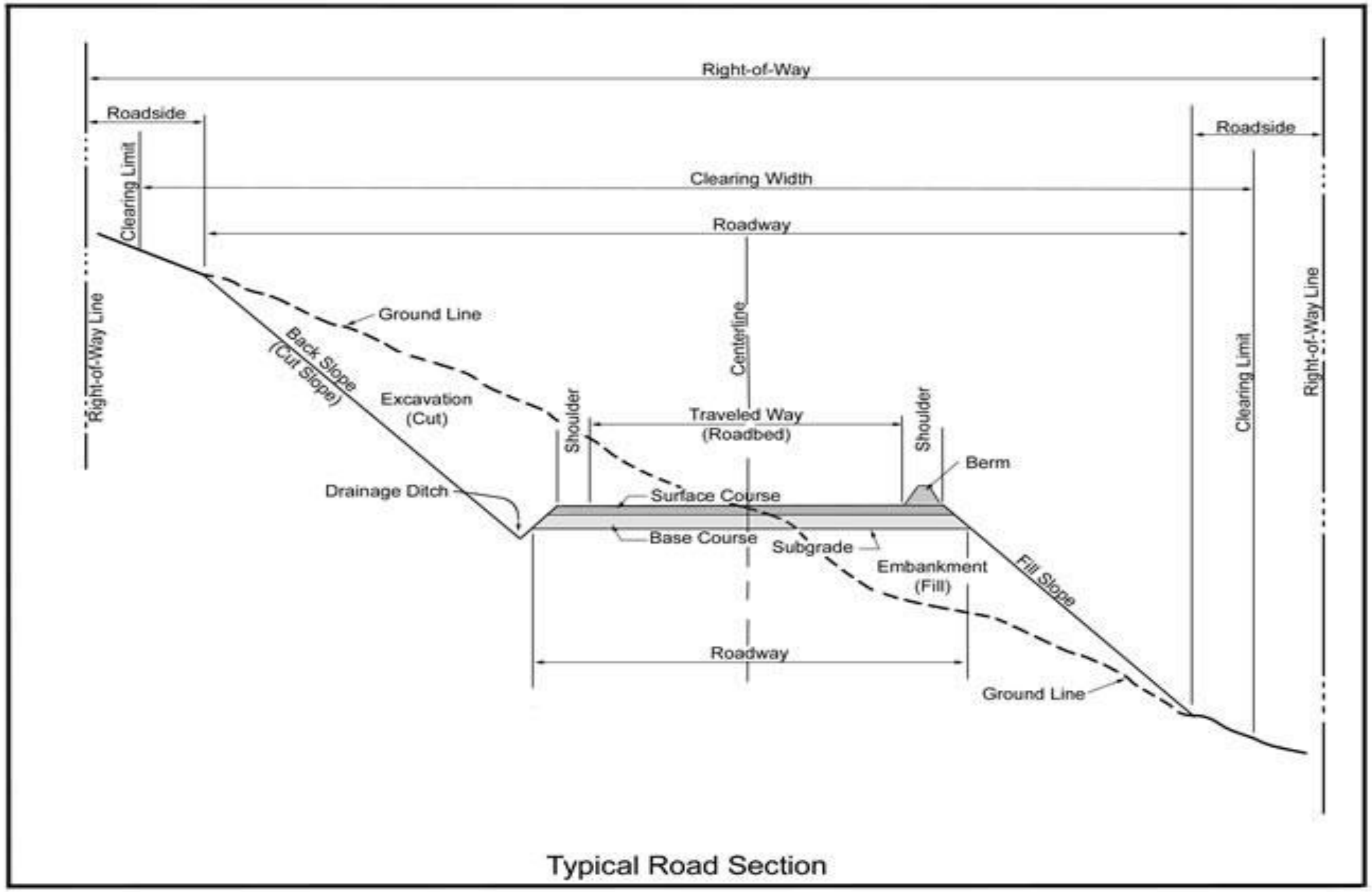

Figure 3.4 A typical road cross section

Design Documents

- It should be noted that ***the plan view*** and ***the profile*** are not *orthogonal views* – horizontal distance in the profile is measured along the centerline, as if the facility were "stretched out"- not along the arbitrary x-axis.

- The line representing the facility on the profile is called ***profile grade*.** For most highway applications, the profile grade represents the elevation of the pavement at the centerline of the facility. For multilane divided highways, it may represent the elevation of the inside edge of the pavement. In other words, unless otherwise specified, for a straight section, profile grade represents the highest point on the surface of the facility.

Design Documents

- Locations along the centerline are identified by *stations*.
- Distances along the centerlines may be measured in distances or stations. A distance of 1024.5 m will be 1+024.5 station,
- *Elevations* are in meters above some datum
- *Grades* (longitudinal slopes) are expressed as decimal fractions (m/m)
- *Cross-slopes* are normally specified in m/m or in percentage

HIGHWAY DESIGN PROCESS

HIGHWAY DESIGN PROCESS

Highway design process requires the determination of a variety of design elements. The geometric design features of a highway can be listed as

- The geometric class of the highway,
- number of lanes, lane width,
- shoulder width,
- median if available,
- elements of horizontal and vertical alignment,
- acceleration and deceleration lanes, climbing lanes.

Pavement structure and accessories such as retaining walls, drainage structures, guardrails, fences and similar can also be counted as components to be designed.

They require special attention considering both structural and traffic safety aspects.

HIGHWAY DESIGN PROCESS

Initial step in highway design is the decision making process, generally called as *feasibility study*, which requires a compact research covering extensive surveys, future traffic estimations, a preliminary design and economic analysis. During this phase of the process the location, the geometric class and the functional category of the highway to be designed are fixed and thus the design standards to be applied are also selected.

The design standards for different classes of highways are developed considering the demand level at one hand and road-vehicle-driver system at the other.

In this chapter, highway location and geometric design elements and design criteria for highways and highway design standards will be discussed.

General Considerations in Locating Highways

There are many operational, environmental and social factors that affect and/or control the location of highways. Strategies are developed to consider these factors through defining control points to achieve proper highway location.

A ***control point*** is a locality which determines directly or indirectly the origin and destination, and the physical route between these two points.

General Considerations in Locating Highways

There are two types of control points.

a) **Major Control Points:** A location where the highway must serve definitely. The origin and destination of the highway (a mining area, a railroad station or a harbor, a resort area, cities and similar) and the other locations between origin and destination which the highway must serve are major control points. Such control points cannot be avoided.

b) **Minor Control Points:** Minor control points also affect the locations of a highway, but they can be avoided when necessary. Low lying areas object to flooding, swamps, wooded areas, educational and medical centers, historical buildings, entrances to cities are among minor control points.

General Considerations in Locating Highways

The following items can be considered in detecting major and minor control points and will be helpful in selection of highway location.

1- The highway should be able to serve the development of a convenient, continuous, and free-flow of traffic

2- Grades and amount of curvatures should be as low as possible.

3- Avoid sudden changes in the sight distance.

4- Avoid having a horizontal curve on or adjacent to a vertical curve.

5- In urban areas, locate the highway on undeveloped areas rather than highly developed expensive areas.

6- In urban areas, locate the highway as close as possible to the parking terminals.

General Considerations in Locating Highways

7- In urban areas, locate the new highway on existing highway to reduce initial and maintenance cost.

8- Locate highway on the edges of private property rather than crossing it in the middle.

9- Avoid the destruction or removal of man-made culture

10- Keep the highway away from cemeteries, places of worship, hospitals, schools and playgrounds.

11- The effect of highway on the development of the adjacent area must be considered so that needs for future changes will not be too costly.

12- Never have too roads intersecting near a horizontal curve or at the top or bottom of a hill.

General Considerations in Locating Highways

13- In the case a need for the construction of an interchange, topography must be suitable for such a construction.

14- Avoid intersections at grade with railway lines

15- Try to pass the rivers at right angles

16- Do not have a bridge or tunnel located on or adjacent to a highway curve

17- Avoid the need for deep cuts and expensive tunnel construction

18- Avoid the places where rock is close to surface

19- In hilly terrain, be aware of the possibilities of landslides

20- To minimize drainage problems, select a location on high ground in contrast to one in a valley.

21- Avoid marshes and other low-lying lands subject to flooding

22- Locate the highway on soil which will require least pavement thickness

23- Locate the highway adjacent to the sources of pavement materials

General Considerations in Locating Highways

24- Try to balance cut and fills with minimum haul distances

25- In hilly terrain the highway should cross ridges at their lowest points. This usually results in cheaper construction as well as more economical vehicle operating cost.

26- In hilly country, select a location subject to sunlight and avoid areas where snow and ice will accumulate

27- Avoid the unnecessary and expensive destruction of wooded areas

28- Avoid ground subject to mining settlement

29- Avoid placing the highway at right angles to the natural drainage channels

30- The final engineering location should be based on the combined considerations of safety, usefulness, aesthetics and economy. This will normally also be the one which will best satisfy social and political requirements.

Surveys for Highway Location

The determinant of the alignment may be done either by conventional ground survey methods, or by aerial photogrammetry. While the other simpler techniques are still used for small projects, the use of photogrammetric surveys on big projects is almost universal and becoming more frequent on smaller projects. Adaptation of photogrammetric techniques to computer operators has enabled substantial savings over conventional methods in terms of time and money.

Survey work can be divided into three basic sequential groups:

a) Reconnaissence

b) Preliminary Survey

c) Final Location Survey

Surveys for Highway Location

- The term ***"reconnaissance"*** may be defined as an exhaustive preliminary study of an area in which the improvement is to be made. **The first step** in any reconnaissance is to procure all available pertinent data: These data may be in the form of maps, aerial photographs, charts, or graphs and so on, and may require the application of a large variety of engineering and economic knowledge.
- The purpose of **a *preliminary survey*** is to gather information about all the physical features which affect the tentatively accepted route, and to prepare a preliminary map upon which the final location survey can be made.

  The most likely route selected is that which best satisfies the directness of the route the suitability of the terrain encountered, and the adequacy and economy of crossing at water causes and other transportation routes.

Surveys for Highway Location

- Upon selection of other preliminary route the final location survey is made.

The ***final location*** survey serves the dual purpose of permanently establishing the centerline and collecting information necessary for the preparation of plans for construction.

Centerline status is placed at selected intervals and curves are staked out.

Bench marks are established and cross sections are taken at selected intervals. This information is necessary for accurate determination of existing grade line, design of drainage structures, computation of earth work quantities, and in general, and estimation of work to be done.

Here again the use of photogrammetric methods can effect economies in the final location.

GEOMETRIC DESIGN OF HIGHWAYS

Highway alignment is originally a 3-dimensional problem. The photograph in Fig.3.5 clearly indicates the three dimensional feature of a highway. Fig. 3.6 also illustrates three dimensional character of a two-lane highway from a deriver's perspective.

Figure 3.5 View of a two-lane highway

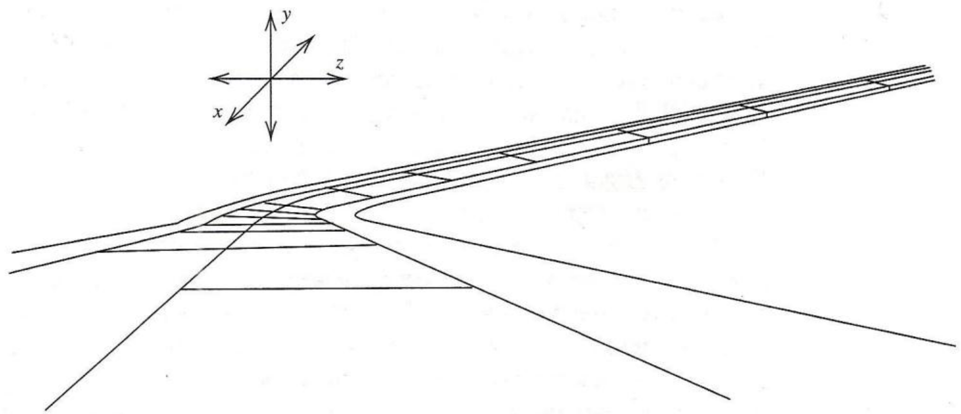

Figure 3.6 Highway Alignment in three dimensions (ref. 1)

However, highway alignment is generally treated as a combined problem of a 2-dimensional problem on plan and a 2-dimensional problem on profile, due to complexity of design computations in three dimensions.

Components of Horizontal and Vertical Alignment

The horizontal alignment is presented on a plan view whereas the vertical alignment is drawn as a profile view as shown in Fig.3.7.

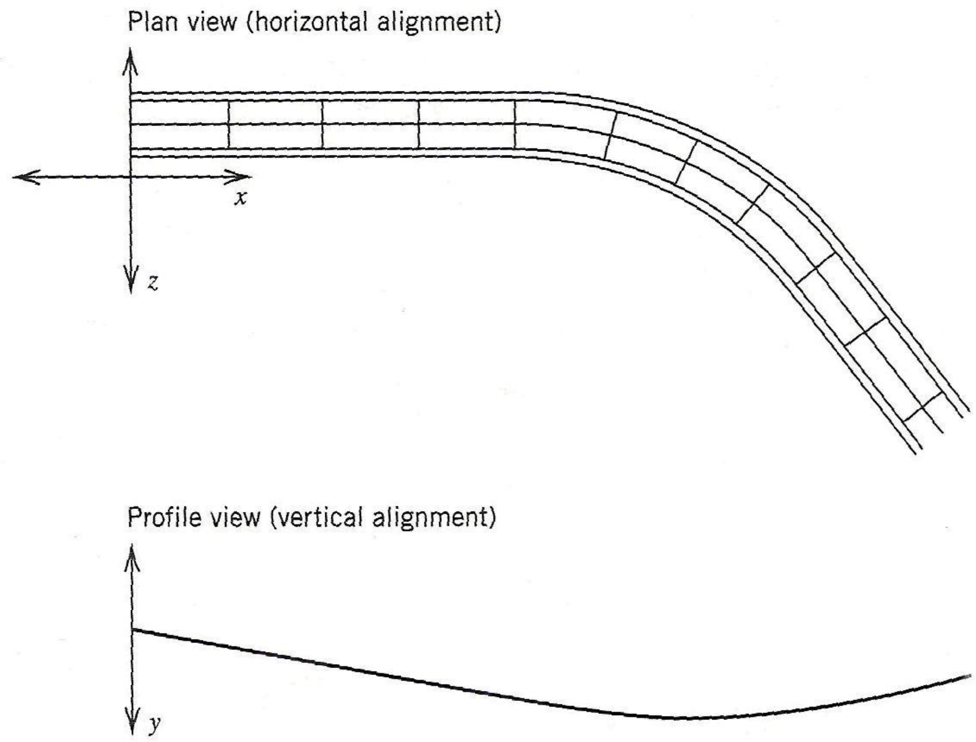

Figure 3.7 Highway alignment in two-dimensional views. (ref. 1)

Cross-section elements

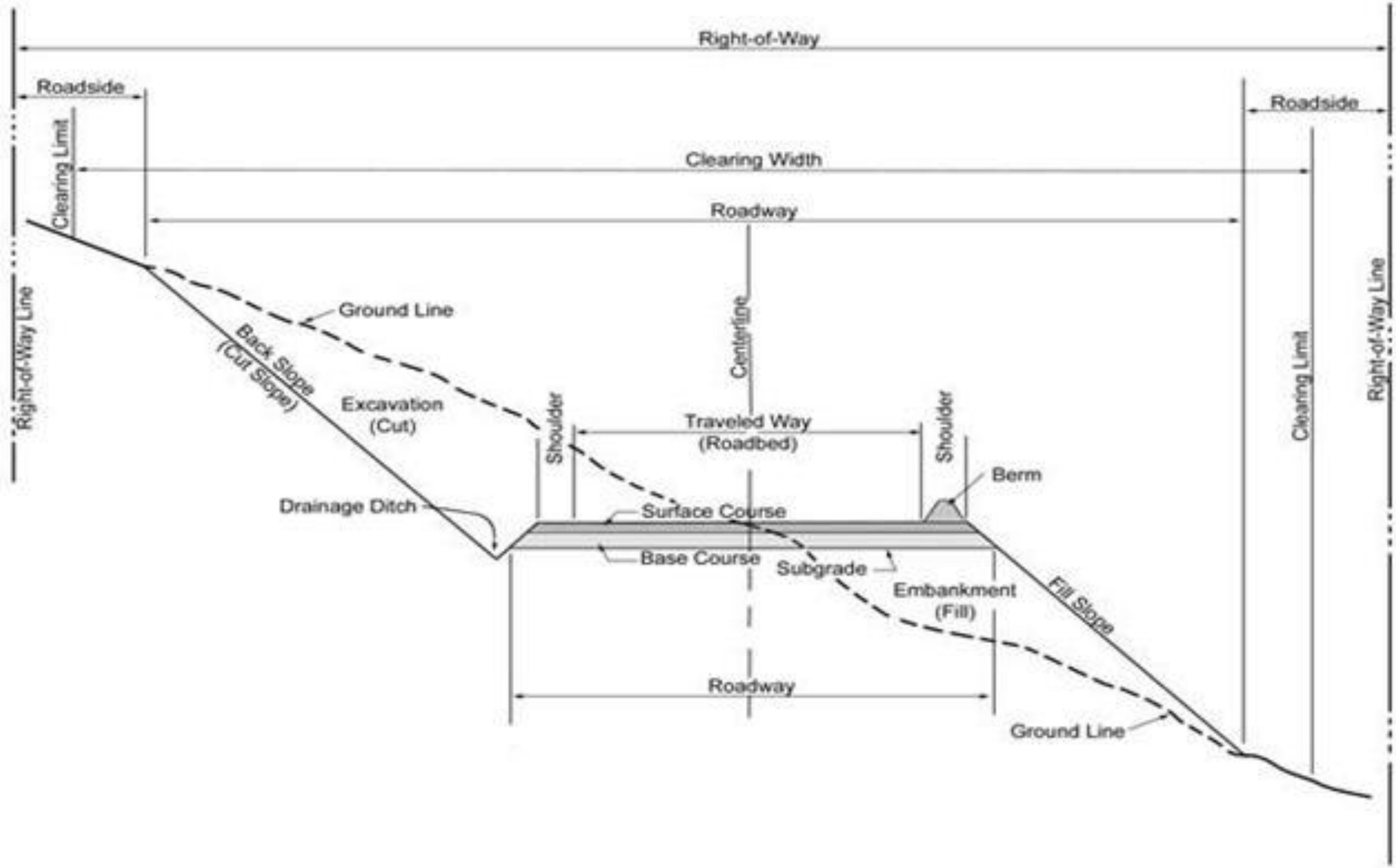

Figure 3.8 A typical cross-section for a two-lane highway

Cross-section elements

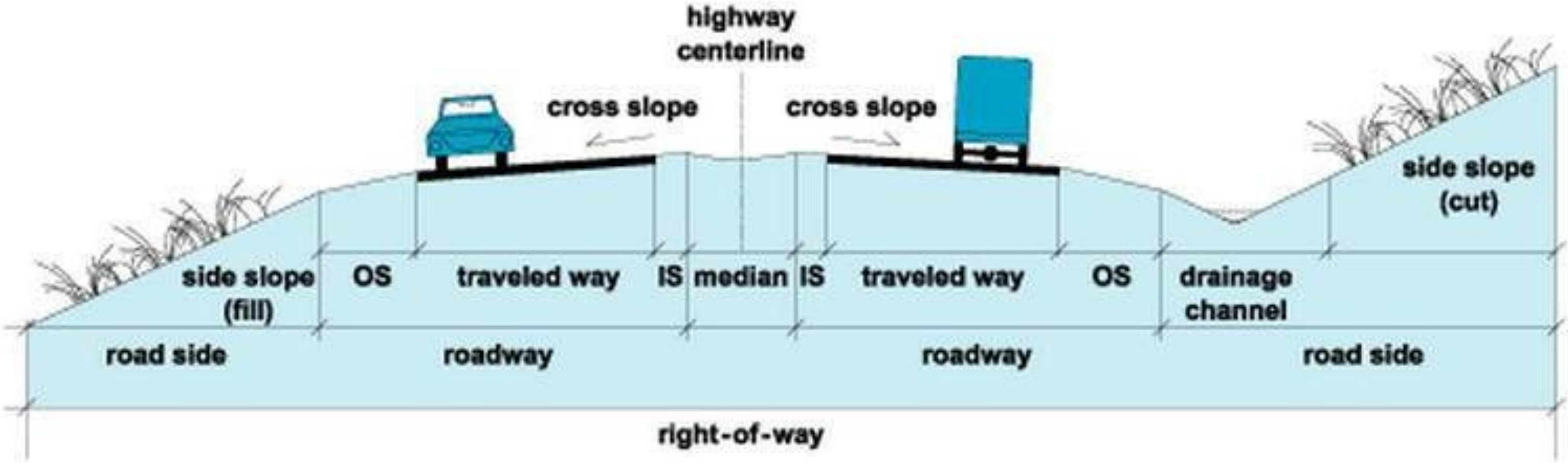

Figure 3.9 Cross section of a divided 2x2 highway