Chapter 6

Drainage and Drainage Structures

INTRODUCTION

- Highway drainage structures are an essential component in the design of a highway. Provision of adequate drainage is an important factor in the location and geometric design of highways.
- It is desirable that they be designed economically and provides an adequate level of service. Factors such as initial cost, design life, and the risk of loss of use of the roadway for a time due to runoff exceeding the capacity of the drainage structure, need to be considered in the design.
- Drainage facilities on any highway or street should adequately provide for the flow of water away from the surface and subsurface of the pavement to properly designed channels and then discharge to the natural waterways.

Inadequate drainage will eventually result in:

i) Serious damage to highway structure

- Reduce pavement strength
- Swelling heave
- Stripping of asphalt
- Cause pumping in rigid pavements
- Fronts heave and reduction of bearing capacity when melting

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- ii) Traffic operation problems
  - Slow traffic movement by accumulated water on the pavement
  - Cause traffic accidents as a result of hydroplaning and loss of visibility from the splash and spray. The importance of adequate drainage is well recognized in highway engineering and about 25 percent of highway construction cost is estimated to be spent for erosion control and drainage structures, such as culverts, bridges, channels, and ditches.

Construction Considerations

- Many serious construction problems arise because important drainage and water related factors were overlooked or neglected in the planning and location phases of the project.

➢ With proper planning, many factors can be avoided or cost effective solutions developed to prevent extended damages. Such factors include:

➢ • ***Soil erosion;***
• ***Sediment deposition;***
• ***Drainage and landslide;***
• ***Timing of project stages;***
• ***Protection of irrigation systems and continued use during construction;***
• ***Protection of streams, lakes, and rivers; and***
• ***Protection of wetlands***

Maintenance Considerations

- Planning and location studies should consider potential erosion and sedimentation problems. If a particular location will require frequent and expensive maintenance due to drainage, alternate locations shall be considered, unless these maintenance costs can be reduced by special design.
- Local experience is the best indicator of maintenance problems and interviews with maintenance personnel and local residents are extremely helpful in identifying potential drainage problems. Reference to highway maintenance, flood reports, and damage surveys is also valuable in evaluating potential maintenance problems

Drainage Surveys

- Since hydraulic considerations can influence the selection of a highway corridor and the alternate routes within the corridor, the type and amount of data needed for planning studies varies widely. These studies depend on such elements as environmental considerations, class of the proposed highway, state of land-use development, and individual site conditions.
- Topographic maps, aerial photographs, and stream flow records provide helpful preliminary drainage data, but historical high-water elevations and flood discharges are of particular interest in establishing waterway requirements.
- Special studies and investigations, including consideration of the environmental and ecological impact, shall be commensurate with the importance and magnitude of the project and the complexity of the problems encountered.

Data Collection

- As part of planning and location studies several categories of data shall be obtained and evaluated, including:

- ***Physical characteristics of drainage basins;***
- ***Maps and topographic data including channel surveys and cross sections***
- ***Runoff quantity data (hydrologic and precipitation data);***
- ***Channel and flood plain delineation and related studies;***
- ***Flood history and problem inventory;***
- ***Existing storm water management structure characteristics;***
- ***Development of alternative plan concepts;***
- ***Hydrologic and hydraulic analysis of alternative concepts***
- ***Consideration of multipurpose opportunities and constraints,***
- ***benefit/cost analysis and evaluation; and***
- ***Runoff quantity data.***

Stream Crossings

- Additional factors to be considered in locating a stream crossing that involves encroachment within a flood plain are:
  - River type (straight or meandering),
  - River characteristics (stable or unstable),
  - River geometry and alignment,
  - Hydrology,
  - Hydraulics,
  - Flood plain flow,
  - Needs of the area, and
- Economic and environmental concerns.

Types of Data

- The following is a brief of the types of data needed for planning and location studies.

1. *Topographic*
2. *Channel Characteristics*
3. *Hydrologic Data*
4. *Catchment Characteristics*
5. *Precipitation*
6. *Flood Data*
7. *High-Water Information*
8. *Existing Structures*

Existing Structures

- Surface drainage encompasses all means by which surface water is removed from the pv't and right of way of the highway or street
- The major source of water for this type of intrusion is surface runoff. An adequately designed surface drainage system will therefore minimize this type of damage. The surface drainage system includes:

i) Transverse slopes
ii) Longitudinal slopes
iii) Longitudinal Channels
iv) Curbs and gutters
v) Cross - Drainage Structures
vi) Sediment and Erosion Controls

Design of surface drainage

- the designed of surface drainage systems for a highway may be divided into three major phases:

(1) An estimate of the quantity of water that may be expected to reach any element of the system;

(2) The hydraulic design of each element of the system; and

(3) The comparison of alternative systems, alternative materials, and other variables in order to select the most economical system that can be devised.

- In the third phase, attention must be given to selecting the system that has the lowest annual cost when all variables are taken into consideration.

Flood Estimation

- Assignment

Q1. clearly estimate the flood estimation methods/approaches have been used to estimate the quantity of runoff for drainage design.

Design of Culverts

- Depending on the class of highway, the volume of the stream flow to be crossed, the site conditions, and economic factors, the flowing cross-drainage structures maybe considered:
  - Fords
  - Drifts
  - Culverts, and
  - Bridges

Hydraulic Design of Culverts

- The purpose of hydraulic design is to provide a drainage facility or system that will adequately and economically provide for the estimated flow throughout the design life without unreasonable risk to the roadway structure or nearby property. Hydraulic design of culverts involves the following general procedure:

1. *Obtain all site data and plot a roadway cross section at the culvert site including a profile of the stream channel.*
2. *Establish the culvert invert elevation at the inlet and outlet and determine the culvert length and slope.*
3. *Determine the allowable headwater depth and the probable depth of tail water during the design flood.*
4. *Select a type and size of culvert that will accommodate the design flow under the established conditions.*
5. *Examine the need for energy dissipaters, and where needed, provide appropriate protective devices to prevent destructive channel erosion.*

Highway Bridges

- The term "Bridge" is usually associated with structures that are required to carry the roadbed over as established waterway; it may also be somewhat loosely applied to grade separation structures and elevated highways in urban areas (viaducts).
- The ideal location for a bridge crossing is, of course, one in which the crossing is made at right angles to the centerline of the stream at the narrowest point, where the alignment of the approach pavement is straight, where the approach grade is slight, and where soil conditions are adequate for the installation of the most economical foundation for the span involved.
- This ideal combination of circumstances is encountered all too infrequently, except in structures of short span, and many bridges have been located on skew crossings, vertical curves, or with curving alignment.
- Many times, alternative locations of proposed bridge may seem to offer somewhat similar advantages. A careful comparison must than be made of the several possible locations.

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- The final decision should be based on a complete analysis, including factors related to traffic safety and operating conditions, fulfillment of the purpose of the road (e.g. the direct connection of population centers) and economy.
- Standards related to bridge clearances, both vertical and horizontal, are an important part of the design of highway bridges. AASHTO specifies that the roadway width at bridges shall be equal to the full shoulder width of the approach section.
- Along curbed roadways, the full width of the approach section should similarly be crossed the structure.
- For low-speed, low volume roads, a minimum horizontal clearance of the width of the approach traveled way plus 2.4m is recommended.
- The vertical clearance of a highway bridge should be at least 4.3m over the entire roadway. Along main highways, a 4.9 m vertical clearance is usually provided.