# FUNDAMENTAL OF IRRIGATION ENGINEERING

# **CHAPTER 1 Introduction**

1.1 Definition

1.2 Lift and Flow Irrigation

1.3 Scope of Subject

1.4 Advantages of Irrigation

1.5 Development of Irrigation in India

# **CHAPTER 2** Water Requirement of Crops

2.1 Functions of Water in Plant Growth
2.2 Soil Moisture
2.3 Consumptive Use of Water
2.4 Factors Affecting Consumptive Use
2.5 Effective Precipitation & Irrigation Requirements
2.6 Irrigation Frequency
2.7 Irrigation Methods
2.8 Quality of Irrigation Water

# **CHAPTER 3 Preparation of a Canal Irrigation Project**

3.1 Irrigation, Navigation and Hydro-electric Canals
3.2 Classes of Irrigation Canals
3.3 Parts of a Canal System
3.4 Preliminary Surveys
3.5 Commanded Areas
3.6 Detailed Survey
3.7 Channel Alignment
3.8 Curves
3.9 Assessment of Water Requirement
3.10 Channel Losses

# **CHAPTER 4 Sediment Transportation-Design of Stable Channels in Alluvium**

4.1 Flow Equation for Uniform Flow in Open Channels 4.2 Formulation of the Problem 4.3 Kennedy's Theory 4.4 Total Silt Transporting Capacity of a Channel According to Kennedy Theory 4.5 Advancement After Kennedy Theory 4.6 Trail Procedure of Design on Kennedy Theory 4.7 Lacey's Theory 4.8 Regime Relationships 4.9 Lacey's Flow Equation 4.10 The Idea of Shock 4.11 Other Regime Equations 4.12 Design Procedure with Lacey's Equations 4.13 Lacey's Equations in Respect of Rivers 4.14 Further Work on Regime Concept in India 4.15 A Review of the Regime Theory 4.16 The Semi Theoretical Approach 4.17 Applications to Stable Channel Design

4.18 Design of Non-Scouring Channels4.19 Silt Distribution Over a Channel Cross-Section4.20 Causes of Silting up and Berming of Channels

# **CHAPTER 5 Design Procedure for an Irrigation Channel**

5.1 The Longitudinal Section5.2 Schedule of Area Statistics & Channel Dimensions5.3 Garret's Diagrams5.4 Lacey's Regime Diagrams5.5 Cross-section of Irrigation Channel

# **CHAPTER 6** Waterlogging and Its Control Lining of Channels and Drainage

6.1 Definition and Effects of Waterlogging 6.2 Causes of Waterlogging 6.3 Anti-Waterlogging Measures 6.4 Advantages and Financial Aspects of Lining 6.5 Properties Determining the Suitability of a Canal Lining 6.6 Types of Lining 6.7 Concrete Lining 6.8 Shotcrete Lining 6.9 Brick Tiles 6.10 Asphaltic Linings 6.11 Linings of Earth Materials 6.12 Stone and Concrete Block Linings 6.13 Sections for Lined Channels 6.14 Drainage Behind Linings 6.15 Comparative Watertightness of Different Types of Linings 6.16 Investigations 6.17 Types of Open Drains 6.18 Design and Maintenance of Open Drains 6.19 Closed Drains 6.20 Spacing of Closed Drains

6.21 Drainage by Pumped Wells

# **CHAPTER 7 Irrigation Outlets**

7.1 Definition and Requirements
7.2 Classes of Outlets
7.3 Non-modular Outlets
7.4 Criteria for Judging Behaviour of Semi-modules and modules
7.5 Types of Semi-modules

7.6 Types of Rigid modules

7.7 Selection of the Class and Type of Outlet

# **CHAPTER 8 Regulation and Control of the Canal System**

8.1 Regulation8.2 Delivery System8.3 Discharge Measurement in Open Channels8.4 The surface Float Method8.5 Double Floats and Velocity Rods

8.6 Discharge Observation by Currentmeter8.7 The Chemical Method8.8 Assessment of Canal Revenue8.9 Efficient Management of Irrigation Water

## **CHAPTER 9** Canal Masonry Works-Principles of Design

9.1 Types of Masonry Works
9.2 Principles ofDesign
9.3 Hydrostatic Pressure of Water
9.4 Determination of the Effect of Seepage
9.5 Theory of Seepage Flow
9.6 Use of Flownet in Design
9.7 Khosla Theory for Determination of Pressure and Exit Gradient
9.8 The Hydraulic Jump
9.9 Location of the Jump on Sloping Glacis
9.10 Uplift Pressure in the Jump Trough
9.11 Pressure Relief by Intermediate Drainage

## **CHAPTER 10 Regulation Works**

10.1 Necessity and Location 10.2 Historical Resume 10.3 Classification of Falls 10.4 The Cistern Element 10.5 Roughning Devices 10.6 Design of Trapezoidal Notch Fall 10.7 Design of Sarda Type Fall 10.8 Montague Type Fall 10.9 Inglis Type Fall 10.10 Comparative Utility of Different Types of Falls 10.11 Functions of the Work 10.12 A Simple Square Design of Head Regulator 10.13 The Venturi Head 10.14 Devices to Control Silt Entry into the Off Taking Channel 10.15 Two Distributary Head Designs Incorporating Silt Control as One of Their Fnctions 10.16 Cross Regulation 10.17 Escapes 10.18 Bed Bars

#### **CHAPTER 11 Cross Drainage Works**

11.1 Necessity and Types
11.2 Aqueducts and Syphon-aqueduct-general
11.3 Classification of Aqueducts and Syphon-Aqueducts
11.4 Waterway and Headway Requirements of Aqueducts and Syphon-Aqueducts
Aqueducts and Syphon-aqueducts
11.5 Bank Connections
11.6 Contraction of Canal Waterway
11.7 Discharge Through Inverted Syphon
11.8 Uplift Pressure on the Roof of the Work
11.9 Uplift Pressure on the Floor of the Culverts

11.10 Some Further Remarks on the Design of Syphon Aqueducts and Aqueducts11.11 Example to Illustrate Procedure of Designing a Syphon Aqueduct11.12 Superpassages and Syphons11.13 Level Crossings11.14 Inlets and Outlets

## **CHAPTER 12 Canal Headworks**

12.1 Functions of Headworks 12.2 Location of Headworks 12.3 Layout of Headworks 12.4 The Weir 12.5 The Under-sluices 12.6 The Divide Wall 12.7 The Fish Ladder 12.8 The Canal Head Regulator 12.9 River Training Works 12.10 Design of Weirs on Permeable Foundations, Data Required 12.11 The Factors to be Decided 12.12 Effects of Construction of a Weir on River Regime 12.13 Basis of Design 12.14 Design for Surface Flow 12.15 Design for Sub-surface Flow 12.16 Example in Weir Design 12.17 Silt Control at Headworks - Still Pond Regulation 12.18 Special Works to Control Silt Entry 12.19 Curved Approach

# **CHAPTER 13 River Control**

13.1 Scope and Objectives of River Control
13.2 Classification of Rivers
13.3 Classification of River Training
13.4 Methods of River Training
13.5 Marginal of Embankments or Levees
13.6 Guide Banks
13.7 Spurs or Groynes
13.8 Cutoffs
13.9 Bank Pitching and Launching Apron
13.10 Pitched Islands
13.11 Sills and Closing Dykes
13.12 Remarks

# chini i Ek i i nyurology

14.1 Definition and Scope
14.2 Hydrologic Cycle
14.3 Application to Engineering Problems
14.4 Peak Flows
14.5 Flood Frequency Methods
14.6 Catchment Area Formulae
14.7 Hydrograph
14.8 Rainfall Analysis

14.9 Infiltration
14.10 The Runoff Process
14.11 The Unit Hydrograph
14.12 Unit Hydrographs from Isolated Unit Storms
14.13 Unit Hydrographs from Major Floods
14.14 Application of the Unit Hydrograph for Obtaining Flood Hydrograph for Designing Purposes
14.15 Estimation of Total Volume of Runoff Over a Relatively Long Period
14.16 Remarks

# **CHAPTER 15 Dams and Reservoirs Investigation and Planning**

15.1 Introduction
15.2 Selection of Dam Site
15.3 Investigations
15.4 Estimation of Required Storage Capacity
15.5 Principles of Reservoir Planning
15.6 Flood Routing
15.7 Reservoir Losses
15.8 Reservoir Sedimentation
15.9 Reservoir Economics
15.10 System Analysis
15.11 Types of Dams and Their Characteristics

## **CHAPTER 16 Earth and Rockfill Dams**

- 16.1 Introduction 16.2 Foundation for Earth Dams 16.3 Materials for Earth Dams 16.4 Criteria for Safe Design of Erath Dams 16.5 Safety Against Overtopping 16.6 Determination of the Line of Seepage 16.7 Control of Seepage in Earth Dams 16.8 Stability of Slopes 16.9 Foundation Shear Stresses 16.10 Other Criteria 16.11 Typical Sections of Earth Dams 16.12 Compaction of Rolled Fill Dams 16.13 Example to Check the Stability of an Earth Dam 16.14 Rockfill Dams 16.15 Cross-sections of Some Important Embankment Dams **CHAPTER 17 Gravity Dams**
- 17.1 Forces Acting on a Dam
  17.2 Methods of Analysis of a Gravity Dam
  17.3 Modes of Failure and Factors of Safety
  17.4 Elementary Profile of a Gravity Dam
  17.5 The Principal and Shear Stresses
  17.6 Design Procedure
  17.7 Example of Stability Analysis of Gravity Dam
- 17.8 Control of Cracking in Concrete Dams
- 17.9 Galleries in Dams

#### 17.10 Foundation Treatment

#### **CHAPTER 18 Spillways**

18.1 Spillway Capacity
18.2 Types of Spillways
18.3 The Overfall Spillway
18.4 The Trough Spillway
18.5 Side Channel Spillway
18.6 The Shaft Spillway
18.7 Siphon Spillway
18.8 Energy Dissipation Below Spillways
18.9 Forms of the Jump & Design of Stilling Basins
18.10 Spillway Crest Gates
18.11 Types of Gates

#### **CHAPTER 19** Wells and Tubewells

19.1 Introduction 19.2 The Specific Yield 19.3 Safe Rate of Withdrawal 19.4 Deep and Shallow Wells 19.5 The Depression Head 19.6 Construction of Wells 19.7 Depth to Which a Well Should be Sunk 19.8 Indigenous Methods of Raising Water 19.9 Duty of Well Water 19.10 Comparative Advantages of Canal and Well Irrigation 19.11 Types of Tubewells 19.12 Screened Wells 19.13 Cavity Wells 19.14 Abyssinian Tubewell 19.15 Theoretical Estimate of Discharge from a Screened Well 19.16 Boring Methods 19.17 Section of Tubewell 19.18 Location and Command of a Tubewell 19.19 Suitability of an Area for Tubewell Irrigation 19.20 Method of Assessment and Distribution 19.21 Comparison of Tubewell and Canal Irrigation

#### **CHAPTER 20 Hydro-electric Power**

20.1 Introduction
20.2 Assessment of Potential
20.3 Pattern of Load
20.4 Classification of Power Plants
20.5 Types of Development
20.6 Types of Turbines and Their Utility
20.7 Layout and Parts of the Generation System
20.8 The Power House
20.9 Preliminary Design of Power House Substructure for Reaction Turbines