

Contents

Symbols

PART I	BASIC CONSIDERATIONS	1
One	Introduction	3
	1.1 Need for Control of Seepage	3
	1.2 Examples of Drainage Failures Caused by Piping	5
	1.3 Examples of Failures Caused by Uncontrolled Saturation and Seepage Forces	11
	1.4 How Can Seepage Failures Be Prevented?	17
	1.5 Degree of Conservatism Needed	21
	1.6 Scope of This Work	23
	1.7 Conclusions	24
	References	24
Two	Permeability	26
	2.1 General Considerations	26
	2.2 Coefficient of Permeability	32
	2.3 Factors Influencing Permeability	34
	2.4 Indirect Methods for Determining Permeability	48
	2.5 Laboratory Methods for Determining Permeability	49
	2.6 Field Methods That Depend on Pumping or Changing the Head in Holes	53
	2.7 Field Methods That Depend on Seepage Velocities	76
	2.8 Field Methods That Depend on Observation of Spreading or Receding Groundwater Mounds	78
	References	84
Three	Seepage Principles	86
	3.1 Value of Seepage Theory	86
	3.2 Darcy's Law	87
	3.3 Flow Nets	90

xii CONTENTS

	3.4 Seepage Quantities	107
	3.5 Seepage Forces and Uplift Pressures	110
	3.6 Moving Saturation Lines	127
	3.7 Semiturbulent and Turbulent Flow	139
	References	145
Four	Flow Net Construction	148
	4.1 Introduction	148
	4.2 General Suggestions	149
	4.3 Types of Flow Net	150
	4.4 Confined Flow Systems (Phreatic Line Known)	151
	4.5 Unconfined Flow Systems (Phreatic Line Unknown)	159
	4.6 Composite Sections with Phreatic Line Unknown	163
	Supplemental Reading	172
	References	172
PART II	APPLICATIONS	173
Five	Filter and Drain Design	175
	5.1 Basic Requirements of Filters and Drains	175
	5.2 Prevention of Piping	178
	5.3 Examples of Filter Designs to Prevent Piping	186
	5.4 Permeability Requirements of Filters and Drains	190
	5.5 Examples of the Use of Darcy's Law in the Design of Drains	197
	5.6 Examples of the Use of Flow Nets in the Design of Drains	201
	5.7 Use of Synthetic Filter Fabrics in Drains	207
	5.8 Specifications for Filters and Drains	216
	References	218
Six	Seepage Control in Earth Dams and Levees	221
	6.1 General	221
	6.2 Seepage Control by Methods That Reduce Quantity	228
	6.3 Seepage Control by Drainage Methods	246
	6.4 Protecting From Earthquakes and Earth Movements	265
	6.5 Nonsteady Seepage in Dams and Levees	271
	6.6 Rehabilitation of Water-Endangered Dams	274
	6.7 Summary	277

	Supplemental Reading	278
	References	278
Seven	Foundations	281
	7.1 Construction Dewatering	281
	7.2 Foundation Improvement by Drainage	306
	References	329
Eight	Slope Stabilization with Drainage	332
	8.1 General Considerations	332
	8.2 Influence of Important Conditions on Slope Stability	347
	8.3 Drainage Methods for Stabilizing Slopes	361
	8.4 Influence of Soil and Geological Details on Drainage	375
	8.5 General Conclusions	377
	References	378
Nine	Roads, Airfields, and Other Surface Facilities	381
	9.1 Importance of Protecting Paved Areas from Water	381
	9.2 Physical Factors Compounding the Problem of Draining Pavements and Other Surface Facilities	385
	9.3 The Basic Solutions	390
	9.4 Roadbed Drainage	394
	9.5 Airfield Drainage	414
	9.6 Miscellaneous	417
	9.7 Rehabilitation of Water-Damaged Pavements	421
	9.8 Agricultural Lands	423
	References	430
Ten	Structural Drainage	433
	10.1 Problems of Structures Caused by Water	433
	10.2 Retaining Structures	435
	10.3 Partly Submerged Structures	447
	10.4 Masonry Dams	465
	10.5 Storage Reservoirs	475
	10.6 Waste Disposal Structures and Infiltration Ponds	487
	10.7 Overflow Weirs and Spillway Chutes	491
	References	508
Author Index		511
Subject Index		515