Mechanics of Sediment Transportation and Alluvial Stream Problems

R. J. GARDE
K. G. RANGA RAJU
University of Roorkee, Roorkee

STUDI DI TRENTO
BIBLIOTECA
UNIVERSITÀ

WILEY EASTERN LIMITED
New Delhi • Bangalore • Bombay • Calcutta

Contents

1 INTRODUCTION

Sediment and Fluvial Hydraulics 1
Nature of Sediment Problems 2
Scope 8
References 10

2 ORIGIN AND PROPERTIES OF SEDIMENTS

Introduction 11
Origin and Formation of Sediments 11
Fundamental Properties of Individual Sedimentary Particles 13
Bulk Properties of Sediments 30
References 43

3 INCIPIENT MOTION OF SEDIMENT PARTICLES

Introduction 45
Competent Velocity 46
Lift Concept 49
Critical Tractive Force 50
General Comments on Critical Tractive Stress 64
Critical Tractive Stress of Cohesive Materials 66
References 67

4 REGIMES OF FLOW

Introduction 69
Description of Regimes of Flow 69
Ripple and Dune Regime 74
Antidune Regime 84
Importance of Regimes of Flow 86
Prediction of Regimes of Flow 88
Complexities of Regimes in Natural Streams 94
References 95

5 RESISTANCE TO FLOW AND VELOCITY DISTRIBUTION IN ALLUVIAL STREAMS

Introduction 98

Velocity Distribution and Resistance in Turbulent Flow over Rough Boundaries 99
Resistance to Flow in Alluvial Streams 101
Velocity Distribution in Alluvial Streams 122
References 128

6 BED LOAD TRANSPORT AND SALTATION

Introduction 131
Bed Load Equations 132
Bed Load Equations Based on Dimensional Considerations 137
Semitheoretical Equations 140
General Comments on Bed Load Equations 151
Saltation 152
References 155

7 SUSPENDED LOAD TRANSPORT

Introduction 157
Mechanism of Suspension 158
General Equation of Diffusion 159
Integration of Sediment Distribution Equation 161
General Considerations about Sediment Distribution Equation 164
Assumptions in the Derivation of Sediment Distribution Equation 166
Analysis of Differences between Z_0 and Z Values 168
Prediction of Reference Concentration 169
Method of Integrating Curves of (Concentration × Velocity) 173
Relation between Sediment Discharge and Water Discharge 176
Effect of Temperature on Suspended Load Transport 179
Wash Load 180
References 183

8 TOTAL LOAD TRANSPORT

Introduction 186
Two Approaches to the Problem 186
Microscopic Methods 187
Macroscopic Methods 193
Some Approximate Methods 206
Effect of Hydraulic Conditions on Sediment Transport 209
References 210

9 SEDIMENT SAMPLERS AND SAMPLING

Introduction 212
Bed Load Sampling 213

Suspended Load Sampling 221
Computation of Total Load 232
Bed Material Sampling 232
References 235

10 DESIGN OF STABLE CHANNELS

Introduction 237
Variables in Channel Design and Conditions for Design 239
Secondary Factors Influencing Stable Channel Design 240
Stable Channels Carrying Clear Water in Coarse Noncohesive Material 241
Stable Channels Carrying Sediment-Laden Water in Alluvial Material 248
General Comments on Regime and Tractive Force Methods of Channel Design 263
References 266

11 ALLUVIAL STREAMS AND THEIR HYDRAULIC GEOMETRY

Introduction 268
Geomorphic Cycle 268
Various Stages of Streams 269
Nature of Bed Material 270
Variables in Stream Problems 273
Dominant Discharge 273
Stream Slope 275
Shape of Streams 276
Stream Basin 287
References 288

12 STREAM BED VARIATION IN ALLUVIAL STREAMS

Introduction 290
Continuity Equation for Sediment 290
Equilibrium Depth of Scour in Long Channel Contractions 291
Stream Bed Changes during Floods 293
Degradation 296
Aggradation 306
Silting of Reservoirs 314
Local Scour and Methods of Prevention 325
References 341

13 VARIATION IN PLAN-FORM OF STREAMS

Introduction 345

Secondary Currents 345
Flow in Rigid-Boundary, Open-Channel Bends 349
Scour and Deposition at Alluvial Bends 356
Sediment Distribution in Channel Bifurcations 359
Meandering 361
Lateral Migration of Alluvial Streams 368
Cutoffs 370
Delta Formation 375
References 377

14 SEDIMENT CONTROL IN CANALS

Introduction 380
Methods of Sediment Control 381
Sediment Controlling Actions 383
Details of Sediment Controlling Methods 384
Water Requirements 401
Concluding Remarks 402
References 402

15 RIVER TRAINING AND BANK PROTECTION

Introduction 404
Objectives of River Training and Bank Protection 404
General Considerations 406
River Training for Flood Control 409
River Training for Navigation 416
River Training for Guiding the Flow 426
River Training for Sediment Control 434
Stabilization of Rivers 434
References 435

16 MISCELLANEOUS TOPICS

Introduction 437
Alluvial River Models 437
Mud-Flow 449
Density Currents 450
Sediment Transport through Pipes 459
References 467

AUTHOR INDEX 471

SUBJECT INDEX 477