Table of contents

Preface to the 2nd edition xi
Preface to the 1st edition xiii
Scope of the monograph xv
List of symbols xvii

1 Fundamentals 1
1.1 Sediment transport 1
1.2 Turbulent flow 2
1.2.1 General 2
1.2.2 Vertical distributions of shear stress and flow velocity 3
1.2.3 Average flow velocity 7
1.2.4 Resistance equation 7
1.3 Two-dimensional two-phase motion 8
1.4 Bed-load rate; Bagnold's formula 11
1.5 Vector forms of the bed-load rate 13
1.6 Suspended-load rate 15
1.7 Sediment transport continuity equation 17
1.8 Additional remarks 21
Problems 22
References 25

2 Bed forms 29
2.1 General 29
2.2 Origin of bed forms 29
2.2.1 Dunes and bars 30
2.2.2 Ripples 45
2.2.3 Clarification of "uniform flows" 48
2.2.4 Special aspects 48
2.2.5 Additional remarks: the ongoing debate on the origin of bed forms 49
2.3 Geometry and existence regions of dunes and ripples 50
2.3.1 Introductory considerations 50
2.3.2 Geometric characteristics of dunes 51
2.3.3 Geometric characteristics of ripples 57
2.3.4 Existence regions of dunes and ripples 60
2.4 Geometry and existence regions of bars 61

2.4.1 Existence regions of alternate and multiple bars 61
2.4.2 Geometric characteristics of alternate bars 64
2.5 Final remarks 70
References 71

3 Flow past undulated beds 77
3.1 Flow resistance factor 77
3.1.1 General 77
3.1.2 Resistance factor formula 77
3.1.3 Other methods for determination of c 83
3.1.4 Flow rate as one of the parameters determining c 84
3.1.5 Interrelation between Fr and c 86
3.2 Sediment transport rate of flow past undulated bed 87
3.3 Mechanical structure of flow over dunes 88
Problems 90
References 91

4 Regime channels and their computation 95
4.1 Introduction 95
4.1.1 Empirical regime formulae 95
4.1.2 Rational methods based on extremal hypotheses 98
4.2 Regime-channel defining parameters 99
4.2.1 Regime channel R_1 99
4.2.2 Regime channel R 99
4.2.3 Relation between R_1 and R 101
4.3 Regime flow-width and depth 101
4.3.1 Basic dimensionless formulations 101
4.3.2 The expressions of B_R and h_R 103
4.4 Determination of the regime minimization criterion 105
4.4.1 Basic relations and assumptions 105
4.4.2 Variation of flow energy structure in the flow direction l_c at an instant 110
4.4.3 Variation of flow energy structure with the passage of time Θ 113
4.4.4 Froude number; comparison with experiment 117
4.5 Computation of regime channels R 120
4.5.1 Computation procedure 120
4.5.2 Special case: gravel-like regime channel formation 121
4.5.3 Special case: constant flow width 124
4.6 Other rational methods of computation of regime channels 124
4.7 Representative flow rate 125
Problems 128
References 129

5 Formation of regime channels; meandering and braiding 133
5.1 Meandering and regime development 133
5.1.1 Initiation and subsequent development of meandering 133
5.1.2 Tracing of meander development on the $(Fr; \eta_*)$- and $(B/h; h/D)$-planes 139

5.2 Braiding and regime development 144
5.2.1 Overall description of braiding 144
5.2.2 The role of the slope 145
5.2.3 Tracing of braiding development on the $(Fr; \eta_*)$- and $(B/h; h/D)$-planes 148
5.2.4 Additional remarks on braiding 150
5.2.5 Delta formation 152
5.3 Time development of a single-channel stream 155
5.3.1 Adjustments of channel geometry 155
5.3.2 Development duration 158
5.4 Large-scale bed forms and regime development 159
Problems 160
References 161

6 Geometry and mechanics of meandering streams 163
6.1 Channel-fitted coordinates 163
6.2 Sine-generated channels 164
6.2.1 Definition; geometric properties 164
6.2.2 Dimensionless expression of flow related characteristics 168
6.3 Mechanics of meandering flows 169
6.3.1 Introductory considerations: averaging procedures 169
6.3.2 Structure of meandering flow 170
6.3.3 Cross-circulation 173
6.3.4 The "convective base" 178
6.4 Bed deformation 184
6.4.1 Nature of deformed bed 184
6.4.2 Mechanics of bed deformation 188
6.5 Resistance factor of meandering streams 194
6.6 Additional remarks 198
Problems 200
References 201

7 Meandering-related computations 207
7.1 Vertically-averaged flow in meandering channels 207
7.1.1 Equations of motion and continuity; evaluation of the resistance factor c_M 207
7.1.2 Expression of the resistance factor c_M for a flat bed 212
7.1.3 Variational approach to the determination of a meandering flow 217
7.2 Bed deformation by a meandering flow 224
7.2.1 Computation of the developed bed topography 224
7.2.2 Computation of bed deformation over time 225
7.3 Migration and expansion of meander loops 228
7.3.1 General 228
7.3.2 Normal and radial bank displacement velocities 229
7.3.3 Evaluation of radial bank displacement velocity 230
7.3.4 Migration and expansion components of the radial bank displacement velocity 233

References 243

Appendix A – Sources of dune and ripple data 247
Appendix B – Sources of bar data 251
Appendix C – Sources of friction factor data 253
Appendix D – Sources of regime data 255
Appendix E – Sources of meandering and braiding data 257

Subject index 261