

**PRINCIPLES OF SEDIMENT TRANSPORT**  
**IN**  
**RIVERS, ESTUARIES AND COASTAL SEAS**

**PART I: Edition 1993**

**by**

**Leo C. van Rijn**



**Universiteit Utrecht**  
Department of Physical Geography



**WL | delft hydraulics**

**Other publications:**

*Principles of Fluid Flow and Surface Waves in Rivers, Estuaries,  
Seas and Oceans by Leo C. van Rijn, 1990*

*Principles of Coastal Morphology,  
by Leo C. van Rijn, 1998*

*Principles of Sedimentation and Erosion Engineering in Rivers, Estuaries,  
and Coastal Seas by Leo C. van Rijn, 2005*

*Manual of Sediment Transport Measurements (update 2006)  
by Leo C. van Rijn, 2006*

**Aqua Publications  
The Netherlands  
([WWW.AQUAPUBLICATIONS.NL](http://WWW.AQUAPUBLICATIONS.NL))**

**PRINCIPLES OF SEDIMENT TRANSPORT**  
**IN**  
**RIVERS, ESTUARIES AND COASTAL SEAS**  
**PART I: Edition 1993**

Leo C. van Rijn

Professor Fluid Mechanics and Sediment Transport  
University of Utrecht, The Netherlands

Senior Hydraulic Engineer, Delft Hydraulics  
Delft, The Netherlands



**AQUA PUBLICATIONS**

*Published in The Netherlands*  
*Bound Edition 1993*  
*Paperback Edition 2002*  
*Loose leaf Edition 2005*  
*CD-ROM 2006*

Aqua Publications  
The Netherlands  
(WWW.AQUAPUBLICATIONS.NL)

CIP-DATA KONINKLIJKE BIBLIOTHEEK, DEN HAAG, THE NETHERLANDS

Rijn, Leo C. van

Principles of sediment transport in rivers, estuaries and coastal seas / Leo C. van Rijn - Amsterdam:  
Aqua Publications - I11.  
with ref.  
ISBN 90-800356-2-9 bound  
NUGI 816/831

Subject headings: Sediment transport and fluid mechanics

*Copyright 1993 by Aqua Publications*

All rights reserved. No part of this publication may be reproduced in any form or by any means without the prior written permission of the publisher.

**For those who like sediments**



# CONTENTS PART I

<b>1</b>	<b>INTRODUCTION .....</b>	<b>1.1</b>
1.1	Definitions .....	1.1
1.2	History .....	1.3
1.3	Symbols and units.....	1.4
1.4	Characteristic parameters .....	1.5
<b>2</b>	<b>FLUID VELOCITIES AND BED SHEAR STRESSES.....</b>	<b>2.1</b>
2.1	Introduction .....	2.1
2.2	Currents .....	2.1
2.2.1	Current boundary layer .....	2.1
2.2.2	Hydraulic regimes .....	2.2
2.2.3	Velocity distribution over the depth.....	2.4
2.2.4	Fluid mixing coefficient.....	2.4
2.2.5	Bed-shear stress and bed friction .....	2.5
2.3	Waves .....	2.7
2.3.1	Near-bed orbital velocities .....	2.7
2.3.2	Wave-boundary layer.....	2.9
2.3.3	Hydraulic regimes in waves .....	2.10
2.3.4	Velocity distribution in wave boundary layer.....	2.11
2.3.5	Bed-shear stress and bed friction .....	2.15
2.3.6	Breaking waves .....	2.18
2.3.7	Mass transport in non-breaking waves.....	2.20
2.3.8	Mass transport by breaking waves .....	2.28
2.4	Combined current and waves.....	2.28
2.4.1	Introduction.....	2.28
2.4.2	Wave characteristics.....	2.29
2.4.3	Current velocities and bed-shear stresses.....	2.29
	References.....	2.48
<b>3</b>	<b>FLUID AND SEDIMENT PROPERTIES.....</b>	<b>3.1</b>
3.1	Fluid properties.....	3.1
3.1.1	Introduction .....	3.1
3.1.2	Fluid density.....	3.1
3.1.3	Fluid viscosity .....	3.1
3.2	Sediment properties .....	3.3
3.2.1	Introduction .....	3.3
3.2.2	Density and porosity .....	3.5
3.2.3	Shape.....	3.7
3.2.4	Size.....	3.9
3.2.5	Particle fall velocity .....	3.11
3.2.6	Angle of (natural) repose .....	3.17
	References.....	3.19
<b>4</b>	<b>INITIATION OF MOTION .....</b>	<b>4.1</b>
4.1	Initiation of motion in currents .....	4.1
4.1.1	Introduction .....	4.1
4.1.2	Critical bed-shear stress .....	4.1
4.1.3	Critical depth-averaged velocity .....	4.14
4.1.4	Design of stable channels.....	4.16
4.1.5	Examples and problems .....	4.19

**CONTENTS PART I (continued)**

4.2	Initiation of motion in waves .....	4.23
4.2.1	Critical velocity .....	4.23
4.2.2	Critical bed-shear stress .....	4.23
4.2.3	Examples and problems .....	4.25
4.3	Initiation of motion for combined currents and waves .....	4.27
4.3.1	Critical bed-shear stress .....	4.27
4.3.2	Examples and problems .....	4.29
4.4	Initiation of suspension in currents .....	4.31
4.4.1	Critical bed-shear stress .....	4.31
4.4.2	Critical depth-averaged velocity .....	4.32
4.4.3	Examples and problems .....	4.32
	References.....	4.34
<b>5</b>	<b>BED FORMS.....</b>	<b>5.1</b>
5.1	Introduction .....	5.1
5.2	Bed forms in unidirectional currents .....	5.1
5.2.1	Classification.....	5.1
5.2.2	Shape and dimensions of bed forms .....	5.7
5.2.3	Examples and problems .....	5.22
5.3	Bed forms in non-steady currents .....	5.24
5.3.1	Non-steady river flow .....	5.24
5.3.2	Tidal flow .....	5.28
5.3.3	Examples and problems .....	5.32
5.4	Bed forms in waves .....	5.32
5.4.1	Classification.....	5.32
5.4.2	Shape and dimensions of bed forms .....	5.33
5.4.3	Examples and problems .....	5.42
5.5	Bed forms in currents and waves.....	5.43
5.5.1	Classification.....	5.43
5.5.2	Shape and dimensions of bed forms .....	5.46
5.5.3	Examples and problems .....	5.51
	References.....	5.53
<b>6</b>	<b>EFFECTIVE BED ROUGHNESS .....</b>	<b>6.1</b>
6.1	Introduction .....	6.1
6.2	Current-related bed roughness .....	6.1
6.2.1	Introduction.....	6.1
6.2.2	Available methods.....	6.1
6.2.3	Methods based on bed-form parameters.....	6.1
6.2.4	Methods based on integral parameters .....	6.11
6.2.5	Comparison of methods .....	6.15
6.2.6	Examples and problems .....	6.16
6.3	Wave-related bed roughness.....	6.18
6.3.1	Available method .....	6.18
6.3.2	Examples and problems .....	6.21
6.4	Bed roughness in combined currents and waves .....	6.23
6.4.1	Available method .....	6.23
6.4.2	Examples and problems .....	6.24
	References.....	6.26



**CONTENTS PART I (continued)**

<b>7</b>	<b>BED MATERIAL SUSPENSION AND TRANSPORT IN STEADY UNIFORM CURRENTS</b> .....	<b>7.1</b>
7.1	Introduction .....	7.1
7.2	Bed-load transport .....	7.2
7.2.1	Introduction and definitions .....	7.2
7.2.2	Characteristics of moving bed-load particles .....	7.4
7.2.3	Particle pick-up from the bed .....	7.13
7.2.4	Deterministic bed-load transport formulae.....	7.20
7.2.5	Bed-load transport at low shear stress.....	7.29
7.2.6	Bed-load transport at steep slopes.....	7.29
7.2.7	Bed-load transport of non-uniform material.....	7.33
7.2.8	Comparison of bed-load transport formulae.....	7.38
7.2.9	Stochastic bed-load transport formulae.....	7.38
7.2.10	Examples and problems .....	7.43
7.3	Suspended load transport.....	7.49
7.3.1	Introduction.....	7.49
7.3.2	Mass balance equation suspended sediment.....	7.51
7.3.3	Fluid and sediment mixing coefficient.....	7.53
7.3.4	Concentration profiles.....	7.55
7.3.5	Velocity profiles in lower regime.....	7.59
7.3.6	Reference concentration and reference level.....	7.61
7.3.7	Suspended sediment size in case of non-uniform bed material .....	7.65
7.3.8	Suspended load transport rates .....	7.67
7.3.9	Stratification effects in high-concentration suspensions .....	7.75
7.4	Total load transport.....	7.91
7.4.1	Prediction methods.....	7.91
7.4.2	Comparison of methods .....	7.95
7.4.3	Examples and problems .....	7.98
	References.....	7.105
<b>8</b>	<b>BED MATERIAL SUSPENSION AND TRANSPORT IN WAVES</b> .....	<b>8.1</b>
8.1	Introduction .....	8.1
8.2	Identification of transport processes.....	8.2
8.2.1	Non-breaking waves.....	8.2
8.2.2	Breaking waves .....	8.8
8.2.3	Vector presentation of fluxes .....	8.10
8.3	Analysis of measured concentration profiles and transport rates .....	8.11
8.3.1	Instantaneous concentrations.....	8.11
8.3.2	Time-averaged concentrations .....	8.15
8.3.3	Sediment load and transport rate.....	8.27
8.4	Computation of time-averaged concentration profiles.....	8.35
8.4.1	Introduction.....	8.35
8.4.2	Time-averaged convection-diffusion equation.....	8.36
8.4.3	Particle size of suspended sediment .....	8.38
8.4.4	Sediment mixing coefficient for non-breaking waves.....	8.38
8.4.5	Sediment mixing coefficient for breaking waves .....	8.46
8.4.6	Reference concentration in near-bed region.....	8.48
8.4.7	Methods for computation of time-averaged concentration profiles.....	8.51

**CONTENTS PART I (continued)**

8.5	Computation of sediment transport rates .....	8.58
8.5.1	Introduction .....	8.58
8.5.2	Sediment transport models .....	8.58
8.5.3	Sediment transport formulae .....	8.59
8.5.4	Influence of bed slope on bed-load transport .....	8.67
8.6	Examples and problems .....	8.68
	References.....	8.73
<b>9</b>	<b>BED MATERIAL SUSPENSION AND TRANSPORT IN COMBINED WAVES AND CURRENTS .....</b>	<b>9.1</b>
9.1	Introduction .....	9.1
9.2	Analysis of measured concentration profiles and transport rates .....	9.1
9.2.1	Time-averaged concentration profiles.....	9.1
9.2.2	Sediment transport rates .....	9.9
9.3	Computation of time-averaged concentration profiles.....	9.16
9.3.1	Methods.....	9.16
9.3.2	Comparison of measured and computed concentration profiles.....	9.17
9.4	Computation of sediment transport in non-breaking waves .....	9.24
9.4.1	Methods.....	9.24
9.4.2	Comparison of measured and computed transport rates.....	9.27
9.5	Computation of sediment transport in breaking waves.....	9.29
9.5.1	Methods.....	9.29
9.5.2	Comparison of measured and computed transport rates.....	9.33
9.6	Examples and problems.....	9.34
	References.....	9.37
<b>10</b>	<b>BED MATERIAL TRANSPORT, EROSION AND DEPOSITION IN NON-STEADY AND NON-UNIFORM FLOW.....</b>	<b>10.1</b>
10.1	Introduction .....	10.1
10.2	Sediment transport in non-steady flow .....	10.1
10.2.1	River flow .....	10.1
10.2.2	Tidal flow.....	10.1
10.3	Sediment transport in non-uniform conditions .....	10.10
10.3.1	General.....	10.10
10.3.2	Erosion and scour near structures.....	10.14
10.3.3	Deposition in channels .....	10.19
	References.....	10.29
<b>11</b>	<b>TRANSPORT OF COHESIVE MATERIALS .....</b>	<b>11.1</b>
11.1	Introduction .....	11.1
11.2	Cohesion, plasticity, viscosity and yield stress.....	11.2
11.3	Flocculation .....	11.7
11.4	Settling.....	11.9
11.4.1	Influence of salinity .....	11.9
11.4.2	Influence of concentration.....	11.9
11.4.3	Influence of water depth and flow velocity.....	11.11
11.4.4	Influence of measuring instrument.....	11.12

**CONTENTS PART I (continued)**

11.5	Deposition .....	11.15
11.5.1	Introduction .....	11.15
11.5.2	Concentrations larger than 10 kg/m <sup>3</sup> .....	11.15
11.5.3	Concentrations from 0.3 to 10 kg/m <sup>3</sup> .....	11.15
11.5.4	Concentrations smaller than 0.3 kg/m <sup>3</sup> .....	11.19
11.5.5	Critical bed-shear stress for deposition .....	11.21
11.5.6	Deposition rates.....	11.22
11.6	Consolidation.....	11.22
11.7	Erosion.....	11.28
11.7.1	Introduction .....	11.28
11.7.2	Consolidated hard deposits.....	11.29
11.7.3	Consolidated soft deposits.....	11.31
11.7.4	Erosion rates.....	11.34
11.7.5	Bed forms and roughness .....	11.34
11.8	Transport of mud by currents .....	11.35
11.8.1	(Quasi) steady flow .....	11.35
11.8.2	Non-steady (tidal) flow .....	11.36
11.9	Transport of mud by waves .....	11.42
	References.....	11.46
<b>12</b>	<b>MATHEMATICAL MODELS OF SEDIMENT TRANSPORT.....</b>	<b>12.1</b>
12.1	Introduction .....	12.1
12.2	Flow models .....	12.2
12.2.1	Introduction .....	12.2
12.2.2	Three-dimensional flow models.....	12.3
12.2.3	Two-dimensional horizontal flow model for estuaries and seas .....	12.8
12.2.4	Two-dimensional vertical flow model .....	12.10
12.2.5	One-dimensional flow model for rivers or estuaries .....	12.11
12.3	Wave models .....	12.14
12.3.1	Introduction .....	12.14
12.3.2	Basic equations .....	12.14
12.3.3	Two-dimensional horizontal models for combined refraction, diffraction, shoaling and dissipation .....	12.16
12.3.4	Two-dimensional models for combined refraction, shoaling and dissipation.....	12.21
12.4	Sediment transport and morphological models.....	12.26
12.4.1	Introduction .....	12.26
12.4.2	Basic equations of sediment transport.....	12.26
12.4.3	Three-dimensional models .....	12.38
12.4.4	Two-dimensional vertical models .....	12.42
12.4.5	Two-dimensional horizontal models .....	12.50
12.4.6	One-dimensional models.....	12.55
	References.....	12.58

**CONTENTS PART I (continued)**

**13 MEASURING INSTRUMENTS FOR SEDIMENT TRANSPORT, SETTLING VELOCITY AND WET BULK DENSITY ..... 13.1**

13.1 Introduction ..... 13.1

13.2 Measuring facilities ..... 13.1

13.3 Measuring principles ..... 13.3

    13.3.1 Suspended load transport ..... 13.3

    13.3.2 Bed-load transport ..... 13.4

13.4 Measuring statistics ..... 13.6

    13.4.1 General aspects ..... 13.6

    13.4.2 Sampling site ..... 13.6

    13.4.3 Number of measurements for suspended load transport ..... 13.6

    13.4.4 Number of measurements for bed-load transport ..... 13.15

    13.4.5 Sampling frequency ..... 13.16

13.5 Computation of sediment transport ..... 13.17

    13.5.1 Suspended load transport per unit width ..... 13.17

    13.5.2 Total load transport per unit width ..... 13.22

    13.5.3 Total load transport in cross-section ..... 13.22

    13.5.4 Tide-integrated total load ..... 13.24

13.6 Instruments for bed-load transport ..... 13.25

    13.6.1 Introduction ..... 13.25

    13.6.2 Trap sampling ..... 13.25

    13.6.3 Bed-form tracking ..... 13.32

13.7 Instruments for suspended load transport ..... 13.33

    13.7.1 Introduction ..... 13.33

    13.7.2 Bottle and trap samplers ..... 13.34

    13.7.3 Pump samplers ..... 13.48

    13.7.4 Optical and acoustical samplers ..... 13.53

    13.7.5 Comparison of suspended load samplers ..... 13.60

    13.7.6 Selection of suspended load sampler ..... 13.63

13.8 Instruments for particle size and settling velocity ..... 13.65

    13.8.1 General aspects ..... 13.65

    13.8.2 Sieve instruments ..... 13.66

    13.8.3 Sedimentation methods ..... 13.67

    13.8.4 Coulter Counter ..... 13.72

    13.8.5 In-situ Laser diffraction ..... 13.72

    13.8.6 In-situ video camera ..... 13.73

    13.8.7 Selection of instruments ..... 13.73

13.9 Instruments for bed material sampling ..... 13.74

    13.9.1 Introduction ..... 13.74

    13.9.2 Grab, dredge and scoop samplers ..... 13.75

    13.9.3 Core samplers ..... 13.75

13.10 Instruments for in-situ measurement of wet bulk density ..... 13.76

    13.10.1 General aspects ..... 13.76

    13.10.2 Mechanical core sampler ..... 13.76

    13.10.3 Acoustic probe ..... 13.77

    13.10.4 Nuclear radiation probe ..... 13.77

References ..... 13.81

**APPENDICES**

- A:** TRANSPOR-program; computation of sediment transport in current and in wave direction
- B:** Sand transport in closed conduits
- C:** Side-wall roughness correction method of Vanoni-Brooks
- D:** Pollution aspects of sediments

## **PREFACE**

This book reflects the results of basic research and practical experience in sediment transport and morphology in rivers, estuaries and coastal seas all over the world during a period of about 15 years.

The purpose of this book is to give a unified view of sediment (sand and mud) transport over a wide range of conditions; from quasi-steady river flow to the violent wave-breaking processes in the surf zone of coastal seas. It was not the intention of the author to give a complete overview of the overwhelming amount of literature available. On the contrary, the emphasis is laid on the description and the application of those theories and formulae which have proven to give realistic results based on the authors experience.

The application of refined theories consisting of many complicated equations is often not justified, given the uncertainties of the input data like current velocity, wave height, bed material composition, bed forms and roughness. An elegant way to overcome this problem is to represent the refined model by a much more simple parameter model or computer data base model.

Chapter 2 presents an overview of the near-bed fluid velocities and shear stresses, both being the driving agents of the sediment particle motions. The current boundary layer as well as the wave boundary layer are discussed. Basic wave properties are presented. Mass transport by non-breaking and breaking waves is summarized.

Chapter 3 covers the fluid and sediment properties like density, porosity, shape, size and settling characteristics of the sediment particles.

Chapter 4 presents the processes of initiation of motion and suspension in terms of the critical velocities and bed-shear stresses. Special attention is given to the design of stable channels which is an important aspect of irrigation projects.

Chapter 5 covers the characteristics of bed forms generated by currents alone, by waves and by combined currents and waves. Bed form classification diagrams are given and the shape and dimensions of the bed forms are discussed.

Chapter 6 presents information of the effective (grain and form) roughness of a sediment bed. Methods based on bed-form parameters as well as methods based on integral parameters (velocity, depth, sediment size) are discussed.

Chapter 7 deals with bed load and suspended load transport in steady flow. Both deterministic and stochastic approaches are discussed. The classical diffusion theory is used to describe the distribution of the sediment concentrations over the depth. Special attention is given to stratification effects of high-concentration suspensions.

The Chapters 8 and 9 cover the field of sediment transport by waves and by combined currents and waves. The various transport processes related to breaking and non-breaking waves are identified; high-frequency and low-frequency phenomena are discussed. Emphasis is put on data analysis of concentrations and transport rates measured in flumes, tunnels and in nature.

Chapter 10 is related to the transport of sediments in non-steady and non-uniform conditions. The basic principles of erosion and deposition of sediment particles are presented.

Chapter 11 presents detailed information of the transport of cohesive sediment materials (mud). Basic phenomena like cohesion, flocculation, settling, deposition, consolidation and erosion which take place

in a continuous cycle, are discussed.

Chapter 12 deals with the mathematical modelling of sediment transport and morphology. Three-, two- and one-dimensional models of flow, waves, sediment transport and morphology are presented.

Sediment transport cannot be studied without proper knowledge of measuring instruments. The accuracy of the data is strongly related to the type of instrument applied. Chapter 13 presents a detailed overview of the available measuring principles, statistics, methods and instruments. Simple mechanical and sophisticated optical, acoustical and nuclear instruments are discussed.

The book ends with four appendices. Appendix A presents the TRANSPOR-program (available on CD-ROM) which is the sediment transport model of the author. Appendix B deals with sand transport in closed conduits (pipelines). Appendix C presents a method to eliminate side wall roughness which is necessary for narrow flumes and channels. Appendix D is related to pollution aspects of sediments.

Many calculation examples of available methods and formulae are presented throughout the book, which may help the reader to find a way through the many available equations. A CD-ROM (TRANSPOR1993-program) for computing sediment concentrations, transport rates and bed-form dimensions in a current alone and in combined currents and waves is available to help the reader to solve practical problems.

The present book has been written with a view to morphology of sediment beds. This latter field of work will be described in a forthcoming book: "Principles of Morphology in Rivers, Estuaries and Coastal Seas".

The author hopes that the present book and the TRANSPOR-program will serve as a useful tool for students and graduates in civil engineering, earth sciences, physical geography and oceanography.

Leo C. van Rijn  
Oldemarkt  
January 1993

## **ACKNOWLEDGEMENTS**

The author wishes to acknowledge Delft Hydraulics and the Department of Physical Geography of the University of Utrecht for the typing and the editing of the manuscript.

I am grateful to the discussions and comments of all my national and international colleagues, without whom this book could never have been written.

I am also grateful to the following copyright holders for permission to reproduce figures: Delft Hydraulics, American Society of Civil Engineers, North-Holland Publishing Company, U.S. Geological Survey, Nedeco, D and A Instruments USA.

**ERRATA 1**

Page	Line	Subject
2.5	Line 19	<p>The current-related bed-shear stress can also be expressed as:</p> $\tau'_{b,c} = (1/8)\rho f'_c (u_{\text{mean}})^2 = 0.5 \rho (0.25f'_c)(u_{\text{mean}})^2$ <p>using: <math>u_a = [\ln(30a/k_c)/(-1+\ln(30h/k_c))]u_{\text{mean}}</math>  with <math>u_a</math>=velocity at reference level (a) above the bed, it follows that:</p> $\tau'_{b,c} = 0.5 \rho (0.25f'_c) [(-1+\ln(30h/k_c))/\ln(30a/k_c)]^2 (u_a)^2$ $f'_{c,\text{effective}} = 0.25 f'_c [(-1+\ln(30h/k_c))/\ln(30a/k_c)]^2$ <p>The bed-shear stress can also be determined from:  <math>u_a = (u^*/\kappa)\ln(30a/k_c)</math> or  <math>\tau_{b,c} = 0.5 \rho (2\kappa^2)[\ln(30a/k_c)]^{-2} (u_a)^2</math>  and  <math>\tau'_{b,c} = \mu\tau_{b,c} = 0.5 (f'_c/f_c) \rho (2\kappa^2)[\ln(30a/k_c)]^{-2} (u_a)^2</math></p> <p>This latter equation can also be expressed as:  <math>\tau'_{b,c} = 0.5 \rho (0.25f'_c) [(-0.92+\ln(30h/k_c))/\ln(30a/k_c)]^2 (u_a)^2</math>; which is almost equal to:  <math>\tau'_{b,c} = 0.5 \rho (0.25f'_c) [(-1+\ln(30h/k_c))/\ln(30a/k_c)]^2 (u_a)^2</math></p>

## ERRATA 2

Page	Line	Subject
2.45	Line 5	$k_{a,max}=10k_a$
2.45	Line 19	<i>insert after <math>\tau_{b,cw}</math>-values:</i> according to Equation (2.4.26) and Equation (2.4.27)
2.47	Figure 2.4.13	$\tau_{b,cw}$ refers to flow resistance experienced by the current (Eqs. 2.4.26 and 2.4.27)
3.13	Line 10	Equation (3.2.22) was first proposed by Zanke (1977)
4.5	Figure 4.1.3	$Re_* = u_{*,cr} d/v$
4.7	Figure 4.1.5	Initiation
4.14	Line 24	Equation (4.1.32) only valid for a flat bed
4.23	Line 8	1.45 should read as 1.42
4.30	Line 4	$1.06 \cdot 10^{-4} (\tau_{b,c})^{0.5}$ should read as $1.06 \cdot 10^{-4} / (\tau_{b,c})^{0.5}$
4.30	Line 13	T should read as $T_r$
5.28	Line 7	$q_b$ in $m^2/s$ ; $T_d$ in seconds
5.28	Line 15	$\beta$ should read as $\gamma$
5.44	Line 5,6,7	$u_{*,c}$ should read as $u'_{*,c}$
5.45	Figure 5.5.1	Vertical axis: current-related in stead of wave-related
5.46	Line 17	wave-induced should read as current-induced
5.47	Table 5.3	Maga should read as Mega
5.51	Line 10	Fig. 5.4.6 should read as Fig. 5.5.1
5.51	Line 13	0.306 m should read as 0.306 m/s
5.51	Line 17	0.00194 should read as 0.0194
5.51	Line 23	2D should read as 3D; Fig. 5.4.6 should read as Fig. 5.5.1
5.51	Line 24	Fig. 5.4.7 should read as Fig. 5.5.2
5.52	Line 3	<i>insert after velocities:</i> (parallel to the coast)
5.52	Line 4	<i>insert after wave height:</i> (normal to the coast)
5.52	Line 6	<i>insert:</i> What type of bed forms are present? What are the bed form dimensions?
6.20	Line 6	$(\rho_s - \rho)$
6.20	Line 14	peak wave -related
6.22	Line 1,2,3,4 from bottom	$k_{s,w}$ should read as $k''_{s,w}$
6.24	Line 10 from bottom	$d_{50}=1000 \mu m$ should read as $d_{90}=1000 \mu m$
6.25	Line 3	Eq.(2.4.29) and Eq.(2.4.30)



**ERRATA 3**

Page	Line	Subject
7.33	Line 15	$\varepsilon=(1+\alpha\mu)\mu$
7.62	Line 10	$\theta-\theta_{cr}$ should read as $\theta'-\theta_{cr}$
7.67	Equation (7.3.32)	only valid for $\sigma_s < 2.5$
7.95	Line 7	$10^{-3.46+2.79(\log D^*)-0.98(\log D^*)^2}$ ; last term of exponent to power 2
7.96	Line 1	80% should read as 75%
7.99	Table 7.12	<i>Last column:</i> 0.004 should read as 0.001
7.102	Table 7.14	<i>Last column:</i> 12.4 should read as 19.3 1.8 should read as 4.2 0.12 should read as 0.48 0.03 should read as 0.15 0.003 should read as 0.03
8.4	Line 16	$C_s$ should read as $C_L$ ; $U_L$ and $C_s$ are also not correlated
8.11	Line 13	Wright et al. (1991) should read as Wright et al. (1992)
8.59	Line 6 from bottom	The sediment transport in the onshore (or offshore) period of the oscillatory flow ( $q_w$ ) ...
8.60	Line 18	$q_{w,half}$ =time-averaged transport rate over a half cycle (onshore or offshore period); $q_{w,net}=(T_{on} q_{w,on}+ T_{off} q_{w,off})/T$ ; $T_{on}$ can be computed as: $T_{on}=(U_{off}/(U_{on}+U_{off}))T$
8.60	Line 13 from bottom	$\hat{U}_\delta$ = Peak value of near-bed orbital velocity ( $\hat{U}_{\delta,on}$ or $\hat{U}_{\delta,off}$ )
8.61	Line 11	$f_w$ =friction factor based on particle diameter or sheet flow layer thickness (about 0.01 m)
8.61	Line 12	$\tan\beta$ is positive for upsloping bottom in x-direction
8.62	Line 2	$q_{w,half}$ =time-averaged transport rate over a half cycle (onshore or offshore period); $q_{w,net}=(T_{on} q_{w,on}+ T_{off} q_{w,off})/T$ ; $T_{on}$ can be computed as: $T_{on}=(U_{off}/(U_{on}+U_{off}))T$
8.64	Line 2	$q_{w,half}$ =time-averaged transport rate over a half cycle (onshore or offshore period); $q_{w,net}=(T_{on} q_{w,on}+ T_{off} q_{w,off})/T$ ; $T_{on}$ can be computed as: $T_{on}=(U_{off}/(U_{on}+U_{off}))T$
8.64	Line 24	$T \geq 15$ s should read as $T \geq 12$ s
8.68	Line 7 from bottom	2.7 should read as 2.
8.69	Line 2 from bottom	$T=7$ s should read as $T=12$ s
8.70	Line 7	$f_{w,on}$ should read as $f'_{w,on}$ ; $f_{w,off}$ should read as $f'_{w,off}$
8.70	Line 11	assuming $T_{on}=T_{off}=0.5 T$
10.18	Line 2, 4 from bottom	T in hours
10.19	Line 4	specific
10.19	Line 10, Equation 10.3.10	$\alpha=1+3r_o$ and $r_o$ =turbulence-related coefficient (0.15 for uniform flow)
11.15	Line 18	<b>11.5.2 Concentrations larger than 10 kg/m<sup>3</sup> (hindered settling range)</b>
11.15	Line 6 from bottom	<b>11.5.3 Concentrations from 0.3 to 10 kg/m<sup>3</sup> (flocculation range)</b>
11.34	Line 9	SAR=Sodium Absorption Range;CEC=Cation Exchange Range
A-2	Line 1 from below	exponent should read as -0.25
A-4	Line 7	exponent 0.5 (in bed-shear stress current) should be removed

IN RIVERS, ESTUARIES AND COASTAL SEAS PART I: Edition 1993. by. Leo C. van Rijn. Other publications: Principles of Fluid Flow and Surface Waves in Rivers, Estuaries, Seas and Oceans by Leo C. van Rijn, 1990 Principles of Coastal Morphology, by Leo C. van Rijn, 1998 Principles of Sedimentation and Erosion Engineering in Rivers, Estuaries, and Coastal Seas by Leo C. van Rijn, 2005 Manual of Sediment Transport Measurements (update 2006) by Leo C. van Rijn, 2006. Aqua Publications The Netherlands (WWW.AQUAPUBLICATIONS.NL). C.2. Principles of sediment transport. IN RIVERS, ESTUARIES AND COASTAL SEAS PART I: Edition 1993. Leo C. van Rijn. Professor Fluid Mechanics and Sediment T... Start by marking "Principles Of Sediment Transport In Rivers, Estuaries And Coastal Seas" as Want to Read: Want to Read saving... Want to Read. Currently Reading. Read. Principles Of Sediment by Leo C. van Rijn. Other editions. Want to Read saving... Let us know what's wrong with this preview of Principles Of Sediment Transport In Rivers, Estuaries And Coastal Seas by Leo C. van Rijn. Problem: It's the wrong book It's the wrong edition Other. To ask other readers questions about Principles Of Sediment Transport In Rivers, Estuaries And Coastal Seas, please sign up. Be the first to ask a question about Principles Of Sediment Transport In Rivers, Estuaries And Coastal Seas. Lists with This Book. This book is not yet featured on Listopia. Sediment Transport Primer Estimating Bed-Material Transport in Gravel-Bed Rivers. Description: Sediment Transport Primer Estimating Bed-Material Transport in Gravel-Bed Rivers. Chapter 25 Coastal principles of ecology. no hugot intended Full description. Transport Processes and Separation Process Principles. Rivers of India. Business Plan of SEVEN SEAS. Full description. Sediment transport technology- By Daryl B. Simons- Fuat Ankara. Principles of Growth and Development. Sustainable Transport In Yogyakarta. Studi ini yang merupakan review dari Laporan Studio Pengelolaan Transportasi di Yogyakarta mengungkapkan bahwa, Transportasi di Kota Yogyakarta dalam rencana 20 tahun alias sampai tahun 2031 Deskripsi lengkap.