McGRAW-HILL INTERNATIONAL BOOK COMPANY

New York St. Louis San Francisco Auckland Bogotá Düsseldorf Johannesburg London Madrid Mexico Montreal New Delhi Panama Paris São Paulo Singapore Sydney

Tokyo Toronto

M. E. HARR

Professor of Civil Engineering
Purdue University
West Lafayette
Indiana. USA

Mechanics of Particulate Media A Probabilistic Approach

CONTENTS

vii

	Preface	xi
	English—SI Conversion Factors	xiii
1	Identifying Characteristics	1
1-1	Introduction	1
1-2	Particle-size Characteristics	5
1-3	Particle Shape	14
1-4	Roundness and Sphericity	19
1-5	Phase Relations	21
1-6	Ideal Packings	27
1-7	Problems	32
2	Elementary Probability	38
2-1	Assemblages	38
2-2	Counting Techniques	40
2-3	Randomness and Probability	51
2-4	Conditional Probabilities	61
2-5	Markov Process	72
2-6	Problems	82
3	Equations of Flow	90
3-1	Introduction	90
3-2	Darcy's Law	91

viii CONTENTS

3-3	Equations of Flow	96
3-4 3-5		99
3-3	Problems	101
4	Random Walk—Probability Distributions	104
4-1	Brownian Motion	104
4-2	Random Walk-Binomial Distribution	106
4-3	Properties of Probability Distributions	114
4-4	Random Walk with Spatial Restrictions	123
4-5	The Diffusion Process, Normal Probability	125
4-6	Ensemble; Ergodic Hypothesis	134
4-7	Problems	138
5	Analysis of Flow Systems	142
5-1	Two-dimensional Flow; Monte Carlo Method	142
5-2	Streamlines and Equipotential Lines	148
5-3	The Flow Net	152
5-4	Method of Fragments	158
5-5	Flow in Layered Systems	171
5-6	Piping	174
5-7	Problems	178
6	Elastic Theory (Continuum)	184
6-1	Introduction	184
6-2	Fundamental Relations	185
6-3	Three-dimensional Elastic Systems	193
6-4	Two-dimensional Elastic Systems	200
6-5	Problems	206
7	Probabilistic Theory (Particulate Medium)	215
7-1	Distribution of Stress at a Point	215
7-2	Expected Vertical Normal-stress Distribution	222
7-3	Components of Expected Stress	227
7-4	Distributed Line Loads (Two-dimensional)	230
7-5	Three-dimensional Systems	236
7-6	Distributed Vertical Loads at Surface	241
7-7	Tangential (Horizontal Loads at Surface)	244
7-8	Historical Perspective	247
7-9	Problems	248
8	Coefficient of Lateral Stress (v)	252
8-1	Introduction	252
8-2	Relative Density	253
8-3	Direct-shear Test	257

CONTENTS ix

8-4	Mohr's Diagram	261
8-5		266
8-6		268
8-7		274
8-8	Problems	285
9	Compressibility and Stability	291
9-1	Introduction	291
9-2	Ultimate Bearing Capacity	297
9-3	In-situ Testing	306
9-4		325
9-5	The state of the s	342
9-6	and the same of th	347
9-7	Problems	355
10	Uncertainty and Material Parameters, Sampling	363
10-1	Introduction	363
10-2	Sample Statistics	364
10-3		374
10-4	Regression and Correlation	380
10-5	Testing Hypotheses	384
10-6	Material Parameters as Normal Variates	388
10-7	Density Functions of Material Parameters	394
10-8	Problems	396
11	Reliability	403
11-1	Introduction	403
11-2	Combinatorial Reliability	408
11-3	Capacity-demand Model	413
11-4	Lognormal Distribution	415
11-5	Practical Design Criteria	420
11-6	Bearing Capacity and Reliability	422
11-7	Reliability of Soil Slopes	427
11-8	Decision-making under Uncertainty	442
11-9	Problems	448
	Appendices	455
A	Tables	456
B	Matrix Algebra	465
C	Empirical Distributions	474
C-1	Introduction	474
C-2	Beta Distribution	475
C-3	Moments	477
C-4	Calculation of Moments from Data	481

X CONTENTS

C-5	Approximation by Normal Distribution	485
C-6	Pearson's System	487
C-7	Gamma and Beta Functions	491
C-8	Approximation by Beta Distribution	495
C-9	Taylor Series Approximation	500
C-10	Monte Carlo Simulation	505
	References	513
	Index	537