



# Soil Strength and Slope Stability

*J. Michael Duncan*  
*Stephen G. Wright*



WILEY

JOHN WILEY & SONS, INC.

# CONTENTS

	Preface	ix
CHAPTER 1	INTRODUCTION	1
CHAPTER 2	EXAMPLES AND CAUSES OF SLOPE FAILURE	5
	Examples of Slope Failure	5
	Causes of Slope Failure	14
	Summary	17
CHAPTER 3	SOIL MECHANICS PRINCIPLES	19
	Drained and Undrained Conditions	19
	Total and Effective Stresses	21
	Drained and Undrained Shear Strengths	22
	Basic Requirements for Slope Stability Analyses	26
CHAPTER 4	STABILITY CONDITIONS FOR ANALYSES	31
	End-of-Construction Stability	31
	Long-Term Stability	32
	Rapid (Sudden) Drawdown	32
	Earthquake	33
	Partial Consolidation and Staged Construction	33
	Other Loading Conditions	33
CHAPTER 5	SHEAR STRENGTHS OF SOIL AND MUNICIPAL SOLID WASTE	35
	Granular Materials	35
	Silts	40
	Clays	44
	Municipal Solid Waste	54
CHAPTER 6	MECHANICS OF LIMIT EQUILIBRIUM PROCEDURES	55
	Definition of the Factor of Safety	55
	Equilibrium Conditions	56
	Single Free-Body Procedures	57
	Procedures of Slices: General	63

	Procedures of Slices: Circular Slip Surfaces	63
	Procedures of Slices: Noncircular Slip Surfaces	71
	Assumptions, Equilibrium Equations, and Unknowns	83
	Representation of Interslice Forces (Side Forces)	83
	Computations with Anisotropic Shear Strengths	90
	Computations with Curved Failure Envelopes and Anisotropic Shear Strengths	90
	Alternative Definitions of the Factor of Safety	91
	Pore Water Pressure Representation	95
CHAPTER 7	METHODS OF ANALYZING SLOPE STABILITY	103
	Simple Methods of Analysis	103
	Slope Stability Charts	105
	Spreadsheet Software	107
	Computer Programs	107
	Verification of Analyses	111
	Examples for Verification of Stability Computations	112
CHAPTER 8	REINFORCED SLOPES AND EMBANKMENTS	137
	Limit Equilibrium Analyses with Reinforcing Forces	137
	Factors of Safety for Reinforcing Forces and Soil Strengths	137
	Types of Reinforcement	139
	Reinforcement Forces	139
	Allowable Reinforcement Forces and Factors of Safety	141
	Orientation of Reinforcement Forces	142
	Reinforced Slopes on Firm Foundations	142
	Embankments on Weak Foundations	145
CHAPTER 9	ANALYSES FOR RAPID DRAWDOWN	151
	Drawdown during and at the End of Construction	151
	Drawdown for Long-Term Conditions	151
	Partial Drainage	160
CHAPTER 10	SEISMIC SLOPE STABILITY	161
	Analysis Procedures	161
	Pseudostatic Screening Analyses	164
	Determining Peak Accelerations	165
	Shear Strength for Pseudostatic Analyses	166
	Postearthquake Stability Analyses	169
CHAPTER 11	ANALYSES OF EMBANKMENTS WITH PARTIAL CONSOLIDATION OF WEAK FOUNDATIONS	175
	Consolidation during Construction	175
	Analyses of Stability with Partial Consolidation	176

		Observed Behavior of an Embankment Constructed in Stages	178
		Discussion	179
CHAPTER	12	ANALYSES TO BACK-CALCULATE STRENGTHS	183
		Back-Calculating Average Shear Strength	183
		Back-Calculating Shear Strength Parameters Based on Slip Surface Geometry	185
		Examples of Back-Analyses of Failed Slopes	187
		Practical Problems and Limitation of Back-Analyses	195
		Other Uncertainties	197
CHAPTER	13	FACTORS OF SAFETY AND RELIABILITY	199
		Definitions of Factor of Safety	199
		Factor of Safety Criteria	200
		Reliability and Probability of Failure	200
		Standard Deviations and Coefficients of Variation	202
		Coefficient of Variation of Factor of Safety	205
		Reliability Index	206
		Probability of Failure	206
CHAPTER	14	IMPORTANT DETAILS OF STABILITY ANALYSES	213
		Location of Critical Slip Surfaces	213
		Examination of Noncritical Shear Surfaces	219
		Tension in the Active Zone	221
		Inappropriate Forces in the Passive Zone	224
		Other Details	228
		Verification of Calculations	232
		Three-Dimensional Effects	233
CHAPTER	15	PRESENTING RESULTS OF STABILITY EVALUATIONS	237
		Site Characterization and Representation	237
		Soil Property Evaluation	238
		Pore Water Pressures	238
		Special Features	238
		Calculation Procedure	239
		Analysis Summary Figure	239
		Parametric Studies	241
		Detailed Input Data	243
		Table of Contents	243
CHAPTER	16	SLOPE STABILIZATION AND REPAIR	247
		Use of Back-Analysis	247
		Factors Governing Selection of Method of Stabilization	247

	Drainage	248
	Excavations and Buttress Fills	253
	Retaining Structures	254
	Reinforcing Piles and Drilled Shafts	256
	Injection Methods	260
	Vegetation	261
	Thermal Treatment	261
	Bridging	262
	Removal and Replacement of the Sliding Mass	263
APPENDIX	SLOPE STABILITY CHARTS	265
	Use and Applicability of Charts for Analysis of Slope Stability	265
	Averaging Slope Inclinations, Unit Weights, and Shear Strengths	265
	Soils with $\phi = 0$	266
	Soils with $\phi > 0$	270
	Infinite Slope Charts	272
	Soils with $\phi = 0$ and Strength Increasing with Depth	274
	Examples	274
	References	281
	Index	295