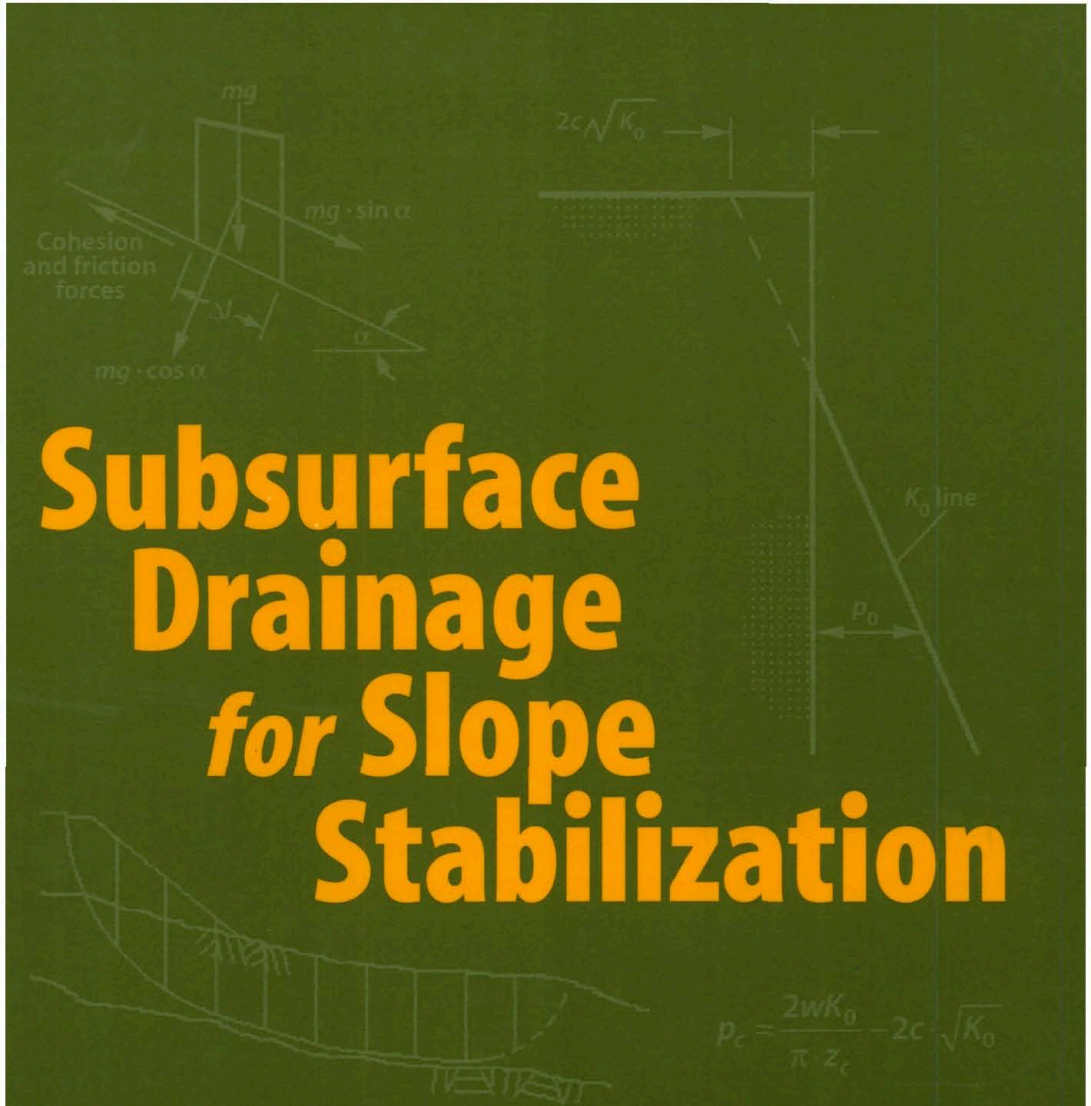

Subsurface Drainage *for* Slope Stabilization

Kevin Forrester

ASCE PRESS

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Abstract: This book describes methods of stabilizing slopes by removing groundwater. After reviewing the ways in which groundwater pressure affects stability and the general principles of reducing it by drainage, chapters give details of the mechanics of flow in soil, rock, aggregates, geotextiles, and pipes. The book presents filtration theory and filter design in a geotechnical context, together with the general characteristics of drains and the assessment of their performance. The materials used in drains as well as construction procedures are also described. The book covers trench, blanket, and horizontal drains, and wells. Also included are discussions of field and laboratory investigations, stability computations, and slope instrumentation and its monitoring. The book ends with an account of clogging mechanisms and maintenance procedures, and an appendix of case examples.

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For my parents,
Charles and Annie Forrester,
and
for former colleagues
of the landslides game

Contents

Symbols and Abbreviations

Symbols

A = area (m^2)
a = distance (m)
B = drain spacing (m)
b = thickness (m)
C_u = coefficient of uniformity
c = cohesion (kPa)
D = diameter; pipe internal diameter (m)
d_x = particle size, x% by mass finer than d (mm or µm)
d_x^f = particle size, x% by mass finer than d in filter (mm or µm)
d_x^p = particle size, x% by mass finer than d in protected material (mm or µm)
F = piezometer tip shape factor (m)
g = acceleration due to gravity (9.81 m/s^2)
H = height; depth of trench (m)
h = piezometric head (m)
Δh = drop in water level (m)
i = piezometric or hydraulic gradient; open channel gradient (sine)
K_0 = coefficient of earth pressure at rest
k = coefficient of permeability (m/s)
k_H = seismic coefficient, horizontal
k_g = coefficient of permeability of geotextile (m/s)
L = length (m)
Δl = element of length (m or mm)
m = mass (Mg)
n = Manning roughness coefficient

n_f = number of channels between flow lines
n_e = porosity
p = piezometric pressure (kPa)
p_c = earth pressure due to compaction (kPa)
p_0 = earth pressure at rest (kPa)
Q = volume flow rate (m^3/s)
Q_{50}, Q_{100} = geotextile flow rate under heads of 50 or 100 mm ($(m^3/s)/m^2$)
q = volume flow rate per unit horizontal width ($(m^3/s)/m$)
q_0 = volume flow rate per unit horizontal area ($(m^3/s)/m^2$)
Δq = incremental volume flow rate per unit horizontal width ($(m^3/s)/m$)
R = Reynolds number
R = radius of influence (m)
R_h = hydraulic radius (m)
r = radius (m)
r_w = internal radius of a well (m)
r_0 = internal radius of pipe to crest of corrugations (mm)
S = storativity
s_u = total strength (kPa)
T = transmissivity ($(m^3/s)/m$)
t = time (s)
t_0 = time intercept on zero drawdown axis (s)
t_b = basic time lag (s)
u = pore pressure (kPa)
V' = volume per unit horizontal area (m^3/m^2)
v_d = discharge velocity, $=Q/A$ (m/s)
v_s = seepage velocity (m/s)
w = uniformly distributed line load (kN/m)
x, y, z = Cartesian co-ordinates
z_c = depth to maximum earth pressure due to compaction (m)
α = angle, slope angle
δ = horizontal deflection (mm)
θ = angular tilt from vertical
λ = axial pitch of pipe corrugations (mm)
ρ = density (Mg/m^3)
ϕ = friction angle
ϕ_r = friction angle, residual shear strength
ψ = permittivity (1/s)

Abbreviations

AASHTO	American Association of State Highway and Transportation Officials
AE	Acoustic emission

AOS	Apparent opening size
ASCE	American Society of Civil Engineers
ASTM	American Society for Testing and Materials
Caltrans	State of California, Department of Transportation
CCTV	Closed circuit television
CDH	California Division of Highways
CRO	Cathode ray oscilloscope
CU	Consolidated-undrained
DMR/RTA	Department of Main Roads/Roads and Traffic Authority, New South Wales, Australia
EDM	Electronic distance measurement
FS	Factor of safety
HDPE	High density polyethylene
ID, OD	Inside, outside diameter
LED	Light-emitting diode
NAVFAC	Naval Facilities Engineering Command, U.S. Navy
pH	Hydrogen potential
PVC	Polyvinyl chloride
RQD	Rock quality designation
SARN	Subaudible rock noise
SPT	Standard penetration test
STP	Special technical publication
TDR	Time domain reflectometry
USBR	United States Bureau of Reclamation
UU	Unconsolidated-undrained
UV	Ultra violet
WAE	Work-as-executed