Introduction to SOIL MECHANICS




Béla Bodó & Colin Jones

WILEY Blackwell

free companion website

Contents

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This book's companion website is at www.wiley.com/go/bodo/soilmechanics and offers invaluable resources for students and lecturers:

- Supplementary problems
- Solutions to supplementary problems

www.wiley.com/go/bodo/soilmechanics

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Preface

This book is intended to introduce the subject to students studying for BTEC Higher National Certificate/Diploma in Civil Engineering and Building Studies or for a Degree in Civil Engineering. It should also be practical reference to Architects, Geologists, Structural and Geotechnical Technicians.

The primary aim is to provide a clear understanding of the basic concepts of Soil Mechanics. We endeavoured to avoid the temptation of over-elaboration by providing excessively detailed text, unnecessary at this early stage of technical studies.

The purpose of this publication is threefold:

1. To introduce the student to the basics of soil mechanics.
2. To facilitate further advanced study.
3. To provide reference Information.

In order to satisfy the above requirements, the concepts of the subject are defined concisely, aided by diagrams, charts, graphs, tables and worked examples as necessary.

The text may appear to be excessively analytical at first sight, but all formulas are derived in terms of basic mathematics, except for a few requiring complicated theory, for those interested in working from first principles. They can be applied however, without reference to the derivation. The expressions are numbered and referred to throughout the text.

There are numerous worked examples on each topic as well as supplementary problems. All examples and problems are solved, many of them interrelated so that solutions can be compared and verified by means of several methods.

Some soil testing procedures are outlined only, as there are a number of excellent, detailed, specialized books and laboratory manuals available to cover this part of the subject.

There is some emphasis on the units employed and on the difference between mass and weight. This subject is discussed in Appendix A.

Béla Bodó and Colin Jones

Dedication

"I dedicate this book to my late wife Dorie."

Béla Bodó

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List of Symbols

Chapter 1

CBR California bearing ratio

C_r Relative compaction

D_r Relative Density

e Voids ratio

G_s Specific gravity

k CBR Load-ring factor

M Total Mass of sample

m Moisture (water) content

m_o Optimum moisture content

M_s Mass of solids

M_w Mass of water

n Porosity

P CBR applied force

P_a Percentage of air voids

Q CBR Load gauge reading

S_r Degree of saturation

V Total volume of sample

V_a Volume of air

V_c Volume of calibrating cylinder

V_s Volume of solids

V_v Volume of voids

V_w	Volume of water
W	Total weight of sample
W_s	Weight of solids
W_w	Weight of water
δ	CBR Penetration distance (delta)
γ	Bulk weight density (Gamma)
γ'	Submerged weight density
γ_d	Dry Weight density
γ_d	Dry Unit weight to be achieved by compaction
γ_s	Weight density of solids
γ_{sat}	Saturated weight density
ρ	Bulk mass density
ρ_d	Dry mass density
ρ_{sat}	Saturated mass density
ρ'	Submerged mass density
ρ_s	Mass density of solids

Chapter 2

C_d Correction for dispersing agent

C_m Meniscus correction

D Equivalent particle diameter

D_{10} Effective size of a particle

f Specific Volume change

H Height from the top of the bulb to surface

h_b Length of bulb

H_R Height of centre of bulb to surface

LI Liquidity index

LL Liquid limit

M_p Mass passing the n^{th} sieve

M_r Mass retained on the n^{th} sieve

m_T Temperature correction

N Number of blows

PI Plasticity index

PL Plastic limit

P_n Percentage of soil passing the n^{th} sieve

R Mixing ratio

R'_h Recorded hydrometer reading

R_h Corrected hydrometer reading

RI Relative consistence index

SL Shrinkage limit

T Temperature

t Time

U Uniformity coefficient

u Velocity of sedimentation

V_b Volume of hydrometer bulb

V_o Volume of over-dried specimen

$\approx$ Volume at SL

x Magnitude of linear shrinkage or swelling

Z Saturation limit

η Dynamic viscosity <eta>

Chapter 3

A	Cross-sectional area of specimen
a	Cross-sectional area of standpipe
A_s	Cross-sectional area of solids in specimen
A_v	Cross-sectional area of voids in specimen
EPL	Equipotential line
FL	Flow Line
F_s	Factor of safety
GL	Ground level
GWL	Groundwater level (Water Table)
h	Head loss
H_T	Total head at x
H_x	Head loss to point x
h_x	Pressure head at x
i	Hydraulic gradient
i_{av}	Average hydraulic gradient
i_c	Critical hydraulic gradient
i_e	Exit gradient
k	Coefficient of permeability
L	Length of flow path
N_e	Number of squares (head drops)
N_f	Number of flow channels

N_x	Number of head drops to point x
P	Hydrostatic force
Q	Flowrate
q	Quantity of flow in time (t)
R	Radius of influence
r	Radius to observation well
r_o	Radius of central well
S	Seepage force
u_x	Seepage pore pressure at x
Δh	Head Loss between equipotential line
υ	Discharge velocity
υ_s	Seepage velocity

Chapter 4

I Influence factor

n Number of elements on the Newmark chart

Q Concentrated point load

q Uniformly distributed load (UDL)

r Radius

z Depth

σ Horizontal pressure

σ_V Vertical pressure

τ Shear stress

Chapter 5

dh	Total deformation of specimen of thickness h
h_A	Artesian pressure head
h_c	Capillary head
h_s	Seepage pressure head
i_c	Critical hydraulic gradient
m_E	Equilibrium moisture content
m_o	Optimum moisture content
pF	Soil suction index
PI	Plasticity index
S_r	Degree of saturation
S_s	Soil suction
T	Surface tension
u	Pore pressure
u_{cs}	Pore pressure in the capillary fringe
u_h	Static pore pressure at depth h
u_s	Seepage pore pressure
z_c	Critical depth for piping
Δu	Small change in u
$\Delta \gamma$	Change in unit weight
$\Delta \sigma$	Small change in σ
$\Delta \sigma'$	Small change in σ'

δ	Deformation of specimen at time t
σ	Total pressure
σ'	Effective pressure
σ_A	Artesian pressure

Chapter 6

A	Pore pressure coefficient
$\bar{A}$	Pore pressure coefficient
B	Pore pressure coefficient
c	Cohesion
c_u	Undrained shear strength
CD	Consolidated-drained test
CU	Consolidated-undrained test
ESP	Effective stress path
NCC	Normally consolidated clay
n	Proving ring constant
OCC	Over consolidated clay
p&q	Stress path coordinates
p_f&q_f	Stress path coordinates at failure
QU	Quick-undrained test
r_x	Force dial reading at x
TSP	Total stress path
UU	Unconsolidated-undrained test
x	Strain gauge reading
Δu_d	Change in pore pressure due to $\Delta\sigma_d$
Δu_c	Change in pore pressure due to $\Delta\sigma_c$
$\Delta\sigma_c$	Change in cell pressure

$\Delta\sigma_d$	Change in the deviator stress
ε	Strain at x
φ	Angle of friction
σ_n	Normal pressure
σ_x	Deviator stress at x
σ_u	Unconfined compression strength
τ	Shear stress
τ_f	Shear stress at failure
τ_p	Shear stress on a plain
τ_m	Maximum shear stress

Chapter 7

A_c Area indicating completed consolidation

A_t Area under an isochrone

a_v Coefficient of compressibility

C_α Coefficient of Secondary settlement () to consolidation

C_c Compression index

C_v Coefficient of consolidation

D_x Dial reading at stage x

dH_i Initial settlement

E Modulus of elasticity

e_0 Initial voids ratio

e_f Final voids ratio

e_s Voids ratio after swelling

e_x Voids ratio at stage x

H Layer thickness

H_0 Flow path

h_x Height of specimen at stage x

I_p Influence factor

k Coefficient of permeability

m_v Coefficient of volume change

OCR Overconsolidation ratio

q	Bearing pressure
T_v	Time factor
t	Time
U	Average degree of consolidation
U_z	Degree of consolidation
u	Pore pressure at time t
u_0	Initial pore pressure
ΔH	Long-term consolidation settlement
$\Delta\sigma'$	Effective consolidating pressure
δ	Depth factor (Delta)
μ	Poisson’s ratio (My)
σ'_x	Effective pressure at stage x

Chapter 8

c_u	Unconfined compression strength
c_W	Adhesion between soil and wall
e	Eccentricity
F_φ	Factor of safety in terms of friction angle
f_{max}	Maximum compressive stress
f_{min}	Minimum compressive stress
F_s	Factor of safety
H	Height of wall
H_0	Height of unsupported clay
K	Coefficient of lateral pressure
K_0	Coefficient of earth pressure at rest
K_a	Coefficient of active earth pressure
K_f	Coefficient of earth pressure at failure
K_p	Coefficient of passive earth pressure
L	Length of slip surface
M_{max}	Maximum bending moment
M_0	Overturning moment
M_R	Resisting moment
P_a	Active force
P_p	Passive force

P_W	Force of water in tension crack
R	Force on wedge
T	Tension force in tie rod
z_c	Pile penetration
z_0	Depth of tension crack
δ	Angle of wall friction
φ'_m	Mobilised friction
μ	Coefficient of friction
σ_a	Active earth pressure
σ_c	Cell pressure in triaxial test
σ_d	Deviator stress in triaxial test
σ_p	Passive earth pressure
σ'_a	Effective active earth pressure
σ'_p	Effective passive earth pressure
σ'_p	Average pressure
τ_f	Shear stress at failure