Symbols and Notation

Symbols are defined where they are introduced. Vectors are indicated by boldface type, for example, **B**, with lowercase boldface letters usually reserved for unit vectors. The summation convention is not used. Matrix notation is used throughout, with ( ) enclosing one- and two-dimensional arrays. Occasionally, { } are used to enclose a column vector. The notation $B(u)$ means that B is a function of u. Dimensions of quantities are sometimes given in brackets, with F = force, L = length, and T = time; for example, the units of stress are given as (FL^{-2}). A dot over a letter or symbol (e.g., $\dot{\sigma}$) usually means differentiation with respect to time. Some of the more commonly used symbols are the following:

$\hat{D}_i$	unit vector parallel to the dip
Δd	change in the length of a diameter of a tunnel or borehole
dev	subscript identifying deviatoric stress components
E	Young's modulus (FL^{-2})
g	acceleration of gravity
G	shear modulus; also, specific gravity
GPa	10^3 MPa
i	angle of the leading edge of an asperity on a joint
I_1, I_2, I_3	invariants of stress
$\hat{I}_{ij}$	unit vector parallel to the line of intersection of planes i and j
k	used for different purposes as defined locally, including conductivity (LT^{-1}) and stiffness coefficients
K	used variously for the bulk modulus, the Fisher distribution parameter, permeability (L^2), $\sigma_{\text{horiz}}/\sigma_{\text{vert}}$, and σ_3/σ_1
l, m, n	direction cosines of a line
ln	natural logarithm
MPa	megapascals (MN/m^2); 1 MPa $\approx$ 145 psi
n, s, t	coordinates perpendicular and parallel to layers (st plane)
n	porosity
$\hat{N}_i$	unit vector perpendicular to layers or joints of one set

p, p_w	pressure, water pressure
p_1, p_2	secondary principal stresses
P	force; also, in Chapter 9, a line load (FL^{-1})
q_f	bearing capacity (FL^{-2})
q_u	unconfined compressive strength
RMR	rock mass rating according to the Geomechanics Classification
S	spacing between joints of a given set
S_i	shear strength intercept according to the Mohr Coulomb relationship ("cohesion")
S_j	shear strength intercept for a joint
T_{MR}	magnitude of the flexural tensile strength ("modulus of rupture")
T_o	magnitude of the tensile strength; uniaxial tensile strength unless indicated otherwise
u, v	displacements parallel to x, y; positive in positive direction of coordinate axis
u_r, v_θ	displacements parallel to r, θ
Δu	shear displacement along a joint; also radial deformation
Δv	normal displacement across a joint
V_l, V_t	longitudinal and transverse stress wave velocities in a bar
V_p, V_s	compressive and shear wave velocities in an infinite medium
$\Delta V/V$	volumetric strain
w	water content, dry weight basis
w_L, w_P	liquid limit and plastic limit
W	weight vector
x, y, z	right-handed Cartesian coordinates
Z	depth below ground surface
γ	weight per unit volume (FL^{-3})
γ_w	unit weight of water
ε, γ	normal and shear strains
η	viscosity ($FL^{-2}T$)
λ	Lamé's constant; also wavelength
μ	friction coefficient (= tan ϕ); also same as η
ν	Poisson's ratio
ρ	mass density ($FL^{-4}T^2$)
σ	normal stress

σ_1, σ_2, σ_3	principal stresses; $\sigma_1 > \sigma_2 > \sigma_3$ (compression positive)
$\sigma_{t,B}$	magnitude of the Brazilian (splitting tension) strength
σ_r, σ_θ	radial and tangential normal stresses
σ'	effective stress
τ	shear stress
τ_p, τ_r	peak and residual shear strength
ϕ	friction angle; variously used as internal and surficial friction angles as defined locally
ϕ_μ	friction angle for sliding on a smooth surface ($i = 0$)
ϕ_j	friction angle for a joint
ψ	angle between the direction of σ_1 and the plane of a joint
$\bar{\omega}$	average displacement of a bearing plate