UNIVERSITY OF BRIGHTON

School of the Environment

BEng CIVIL ENGINEERING

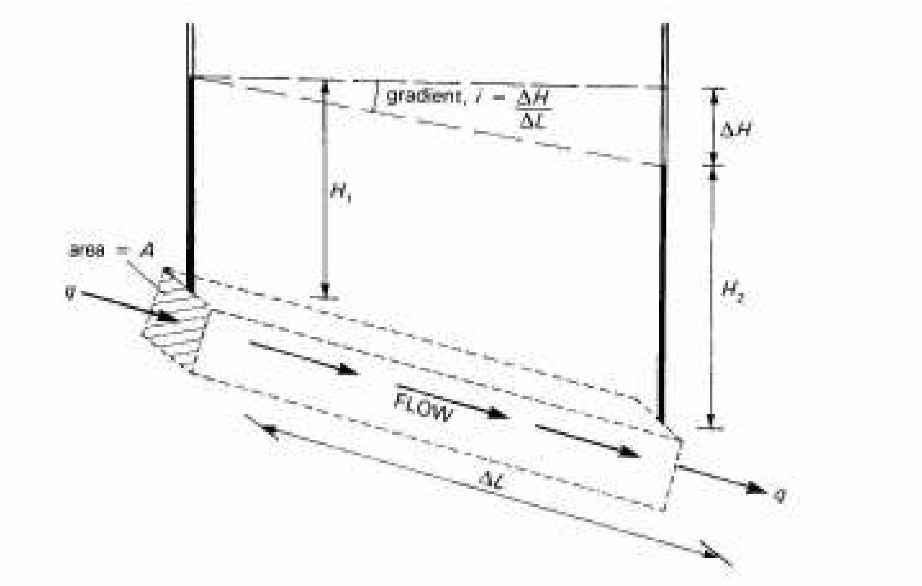
SOIL MECHANICS CN215

Formulae and Design Charts

PHASE RELATIONSHIPS

Term	Symbol	Units	Expression		Formulae
moisture content	w	%	mass water / mass solids	$\frac{m_w}{m_s}$	w is a fraction in formulae below
void ratio (partially saturated)	e	ratio	volume voids / volume solids	$\frac{V_a+V_w}{V_s}$	$e = \frac{n}{1-n} = \frac{wG_s}{S_r}$
void ratio (fully saturated)	e	ratio	volume water / volume solids	$\frac{V_w}{V_s}$	$e = wG_s$
porosity	n	ratio	volume voids / total volume	$\frac{V_a+V_w}{V_t}$	$n = \frac{e}{1+e} = \frac{wG_s}{S_r + wG_s}$
specific volume	v	ratio	total volume / volume solids	$\frac{V_a+V_w+V_s}{V_s}$	$v = 1+e$
degree of saturation	S_r	%	volume water / volume voids	$\frac{V_w}{V_a+V_w}$	$S_r = \frac{\rho_b w G_s}{\rho_w G_s(1+w) - \rho_b} \times 100$
air voids content	A_v	%	volume air / total volume	$\frac{V_a}{V_t}$	$A_v = n(1-S_r)$
particle density	ρ_s	Mg/m^3	mass solids / volume solids	$\frac{m_s}{V_s}$	$G_s \rho_w$
specific gravity	G_s	ratio	solids density / water density	$\frac{m_s}{V_s}\frac{1}{\rho_w}$	$\frac{\rho_s}{\rho_w}$
water density	ρ_w	Mg/m^3	mass water / volume water	$\frac{m_w}{V_w}$	$\rho_w = 1.0\ Mg/m^3$
bulk density (partially saturated)	ρ_b	Mg/m^3	total mass / total volume	$\frac{m_s+m_w}{V_a+V_w+V_s}$	$\rho_b = \frac{G_s(1+w)\rho_w}{1+e}$
bulk density (fully saturated)	ρ_{sat}	Mg/m^3	total mass / total volume	$\frac{m_s+m_w}{V_s+V_w}$	$\rho_{sat} = \frac{(G_s+e)\rho_w}{1+e}$
dry density	ρ_d	Mg/m^3	mass solids / total volume	$\frac{m_s}{V_t}$	$\rho_d = \frac{\rho_b}{1+w}$
bulk unit weight (partially saturated)	γ_b	kN/m^3	total weight / total volume	$\frac{m_t g}{V_t}$	$\gamma_b = \frac{G_s(1+w)\gamma_w}{1+e}$
bulk unit weight (fully saturated)	γ_{sat}	kN/m^3	total weight / total volume	$\frac{m_t g}{V_s+V_w}$	$\gamma_{sat} = \frac{(G_s+e)\gamma_w}{1+e}$
dry unit weight	γ_d	kN/m^3	weight solids / total volume	$\frac{m_s g}{V_t}$	$\gamma_d = \frac{\gamma_b}{1+w}$
unit weight water	γ_w	kN/m^3	weight water / volume water	$\frac{m_w g}{V_w}$	$\gamma_w = \rho_w g = 9.81\ kN/m^3$

PERMEABILITY AND FLOW



The quantity of flow through a given area in a unit time is therefore obtained as

$$q=kAi$$

Properties of a flow net:

Flow nets are constructed so that the intervals between adjacent equipotentials represent a *constant difference in head* (Δh) and the intervals between adjacent flow lines represent a *constant flow quantity* (Δq).

So, the total head loss, H = Δh x no. equipotential intervals
= Δh x Ne

and the total seepage flow, q = Δq x no. of flow intervals (channels)
= Δq x Nf

Isotropic material

$q = k\,\Delta h$ per flow channel per unit length

$q = k\dfrac{H}{N_e}$ per flow channel per unit length

H = total head difference

$Q = k\dfrac{H}{N_e}N_f$ Total flow

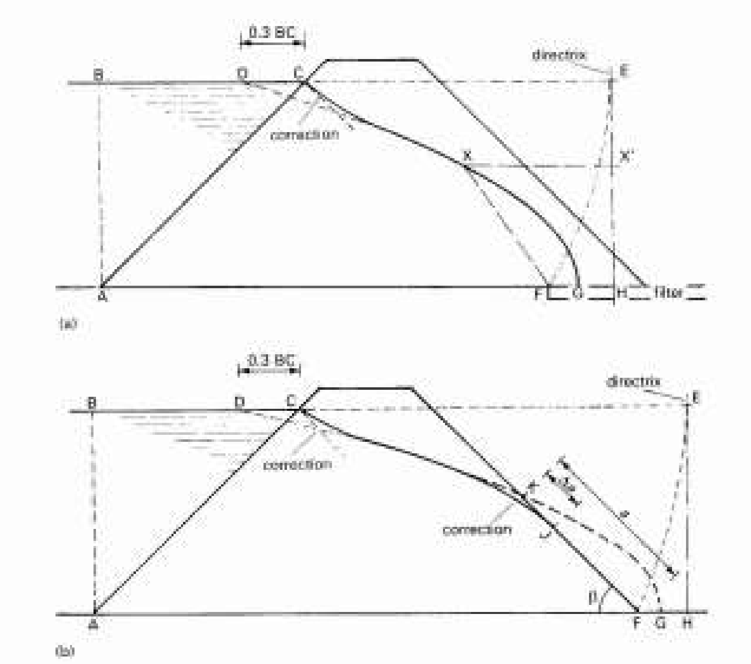
Anisotropic model kh ≠ kv

$$k = k_x \sqrt{\frac{k_y}{k_x}} = \sqrt{k_x k_y}$$

Seepage quantity derived from a transformed flow nets;

$$Q = Ak\frac{N_f}{Ne} = A\frac{N_f}{Ne}\sqrt{k_x k_y}$$

Seepage through earth dams

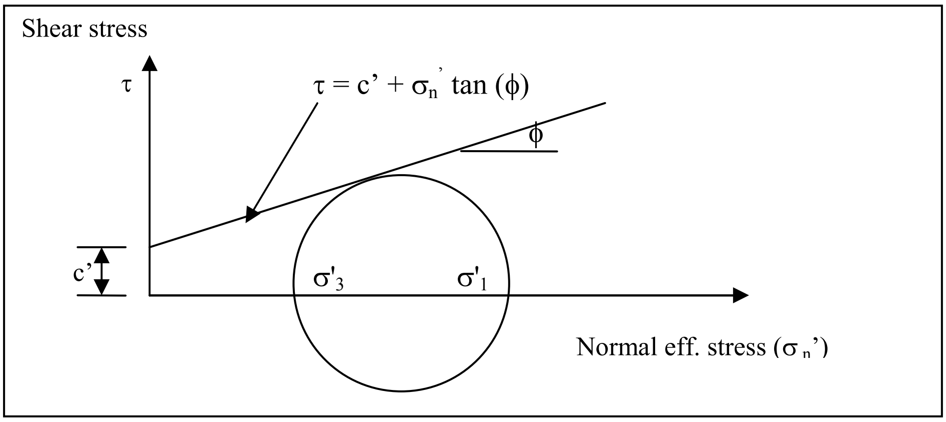


SHEAR STRENGTH

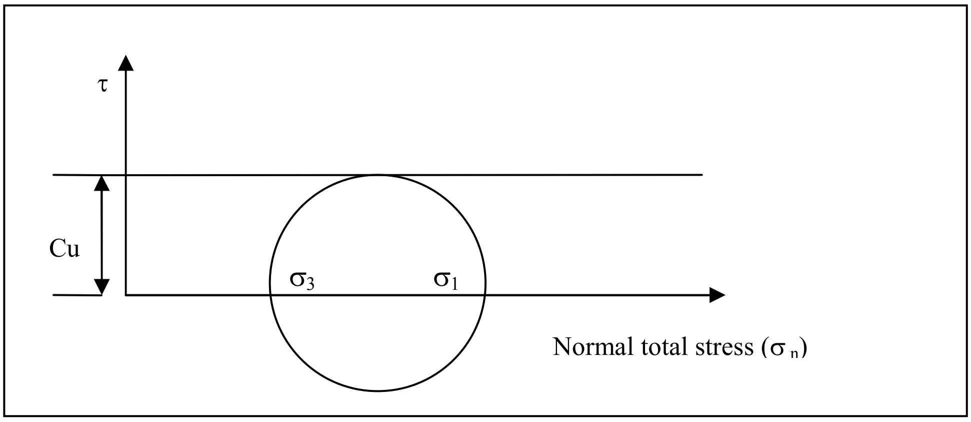
Coulomb's equation

$$\tau = c' + (\sigma_n - u)\tan\phi$$

$$\tau = c' + \sigma_n'\tan\phi$$



MOHR CIRCLE OF EFFECTIVE STRESS



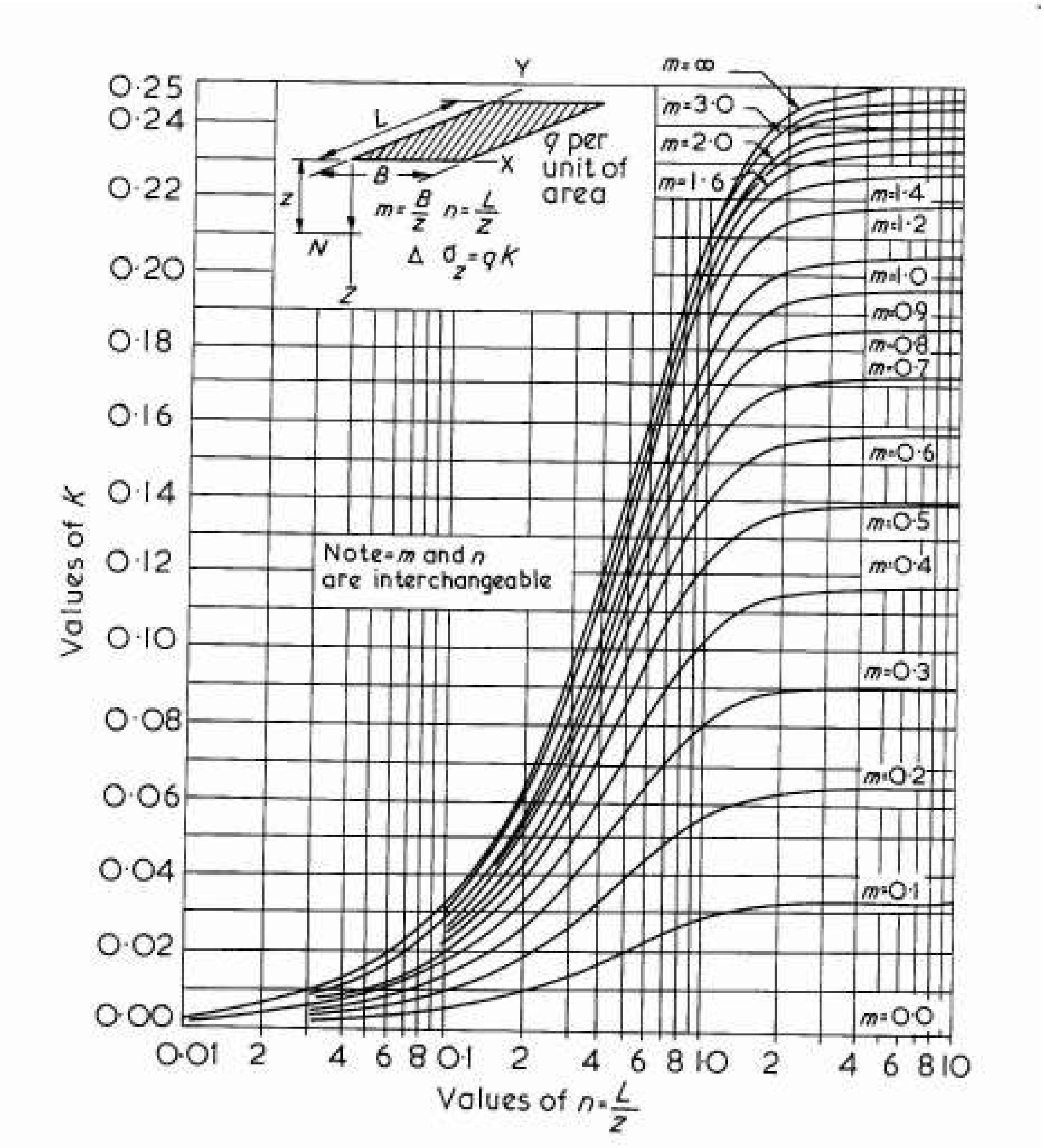
MOHR CIRCLE OF TOTAL STRESS

Deviator stress $q = \sigma_1 - \sigma_3$

Undrained shear strength $Cu = q/2$

STRESS DISTRIBUTION

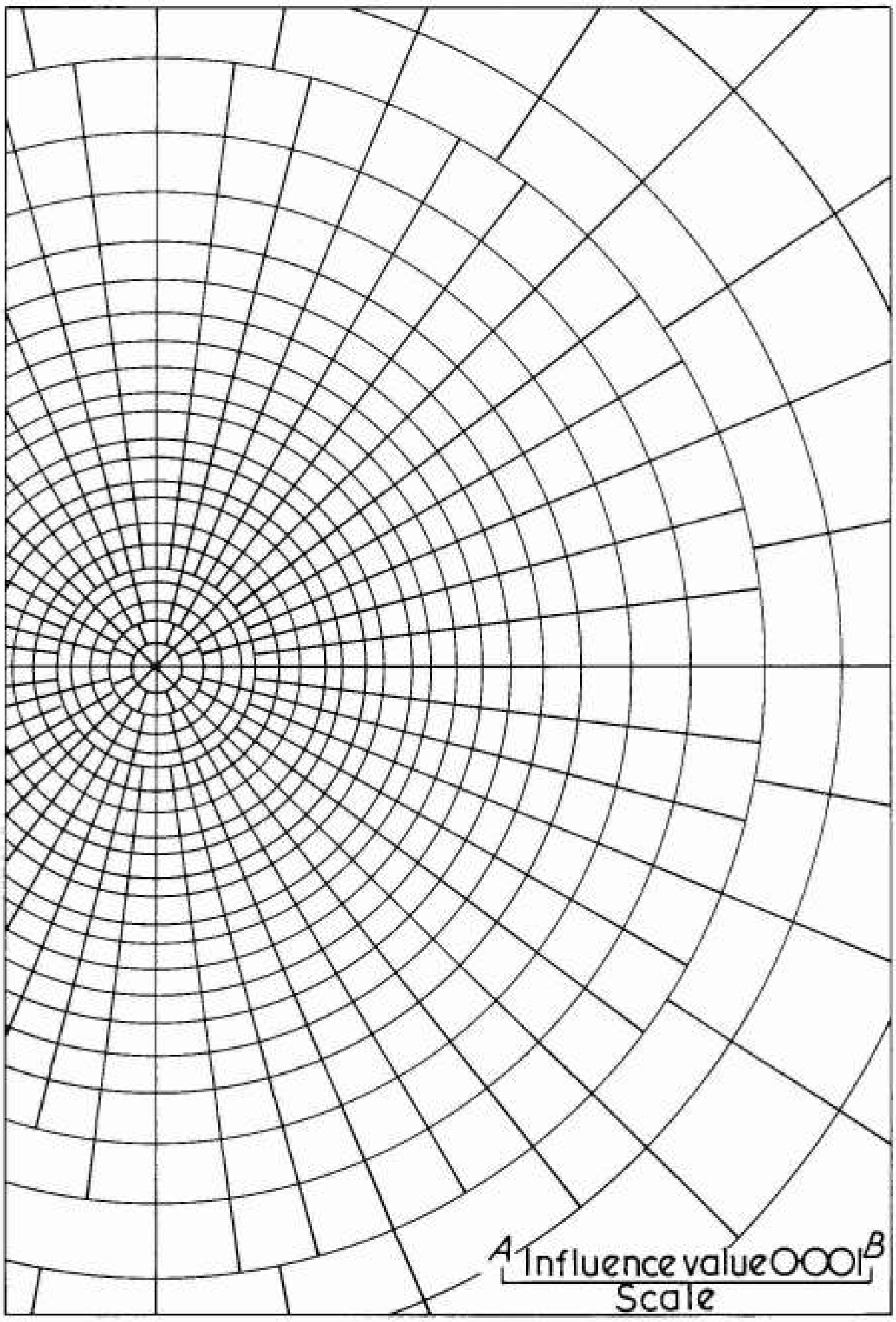
Fadums Chart



Newmark chart

For a uniform loading intensity of q the stress at the required depth below the point in question is computed as $\sigma_v = N \times I_N \times q$

N is the number of segments or part segments, I_N is the chart influence value per field.



DETATCH AND SUBMIT WITH ANSWER PAPER