WEEK 9

1 - Analyse Limite → ELU

x) Fond. SUP.

x) FOND. PROF

2 - TASSEMENTS / CONSOLIDATION ELS

→ Elasticité / drainage

3 - Tests IN SITU.

4 - HYDRAULIQUE

5 - MURS de SOUTÈNEMENT

6. EXCAVATIONS / PAROI MOULÉES

PALPLANCHES

- ANCRAGES

7. PAROI CLOUÉE

2D

$$q_x = -k \frac{\partial h}{\partial x}$$

$$q_y = -k \frac{\partial h}{\partial y}$$

$$\frac{\partial q_x}{\partial x} + \frac{\partial q_y}{\partial y} = 0$$

↳ $\frac{\partial^2 h}{\partial x^2} + \frac{\partial^2 h}{\partial y^2} = 0$ Uniforme

1 champ vectoriel $\underline{V}$

$$\underline{V} = \underline{\nabla} \varphi + \underline{\nabla} \times \underline{A}$$ DÉCOMPOSITION de HELMHOLTZ.

Pour 1 champ irrotationnel → $\underline{A} \equiv 0$

ÉCOULEMENT IRROTATIONNEL (CAS UNIFORME)

$$q_i = \frac{\partial \phi}{\partial x_i} \qquad q_i = -k \frac{\partial h}{\partial x_i} = -\frac{\partial kh}{\partial x_i} = \frac{\partial \phi}{\partial x_i}$$

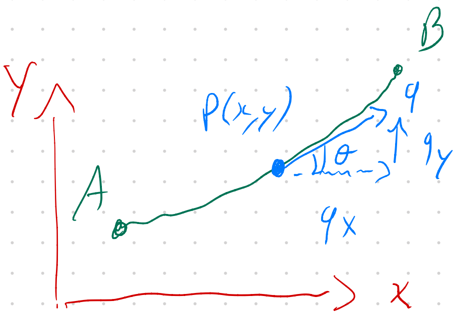
$$q_x = \frac{\partial \phi}{\partial x} \qquad q_y = \frac{\partial \phi}{\partial y} \qquad \left[\phi = -kh + CTE \right]$$

Rotationnel $= 0$ → $\frac{\partial q_x}{\partial y} - \frac{\partial q_y}{\partial x} = 0$ → $\frac{\partial^2 \phi}{\partial y \partial x} - \frac{\partial^2 \phi}{\partial x \partial y} = 0$

ψ Potentiel pour les lignes de COURANTS <u>STREAM LINES</u>

$$q_x = \frac{\partial \psi}{\partial y} \qquad q_y = -\frac{\partial \psi}{\partial x}$$

$$\frac{\partial q_x}{\partial x} + \frac{\partial q_y}{\partial y} = 0 \rightarrow \frac{\partial^2 \psi}{\partial x \partial y} - \frac{\partial^2 \psi}{\partial y \partial x} = 0$$



$$\underbrace{\tan\theta = \frac{q_y}{q_x} = \frac{dy}{dx}}$$

$$\hookrightarrow q_y\, dx - q_x\, dy = 0$$

$$\hookrightarrow \underbrace{+\frac{\partial \psi}{\partial x} dx + \frac{\partial \psi}{\partial y} dy}_{d\psi} = 0$$

ψ = cte $\rightarrow$ Parandhise l'ECOULEMENT $\nearrow$ LIGNE de COURANT

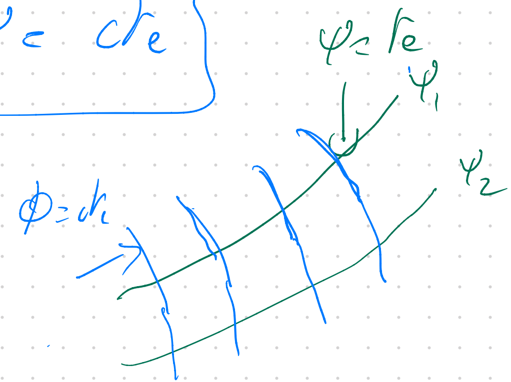
$\psi = cte \rightarrow$ ligne de COURANT $\rightarrow \dfrac{dy}{dx} = \dfrac{q_y}{q_x} = \tan\theta$

$\phi = cte \rightarrow$ EQUIPOTENTIELLE

$$d\phi = 0 = \underbrace{\frac{\partial \phi}{\partial x}}_{q_x} dx + \underbrace{\frac{\partial \phi}{\partial y}}_{q_y} dy = 0$$

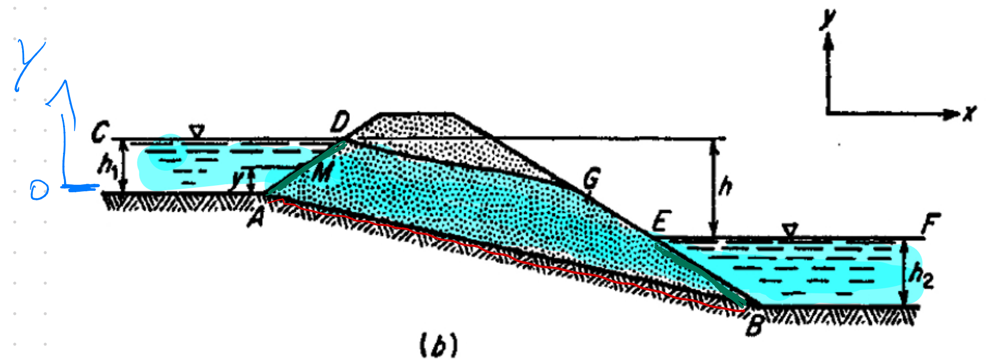
$$\hookrightarrow \quad q_x \, dx = - q_y \, dy \rightarrow \frac{dy}{dx} = - \frac{q_x}{q_y} = - \cot\theta = \tan\left(\theta + \frac{\pi}{2}\right)$$

$$\boxed{\phi = cte \perp \psi = cte}$$



ÉCOULEMENT STATIONNAIRE

CONDITIONS LIMITES

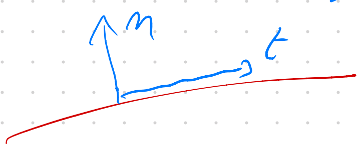


☒ FRONTIÈRE IMPERMÉABLE

ex ligne A-B

$q_i n_i = 0$ $\quad n_i$: la normale à la frontière

$$\frac{\partial \phi}{\partial n} = 0 = \frac{\partial \psi}{\partial t} = 0$$



$\hookrightarrow$ $\psi =$ cte le long de cette frontière

☒ RÉSERVOIR

ex A-D ou E-B

pour AD $\quad u = \gamma_w (h_1 - y) \Rightarrow h = \frac{u}{\gamma_w} + y = h_1$

$\Rightarrow$ $\phi =$ cte le long de cette frontière

☒ SURFACE de SUINTEMENT

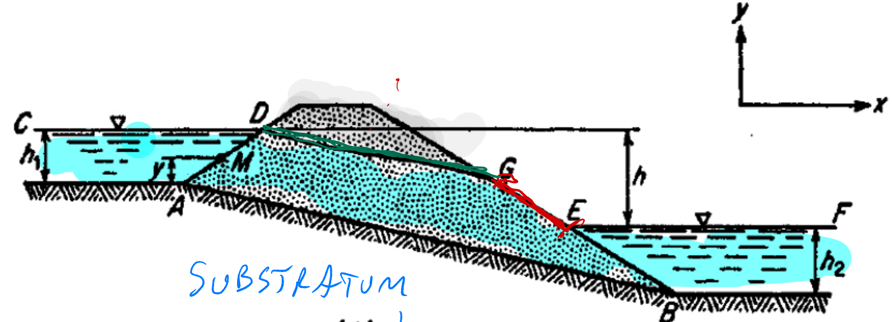
ex ligne G-E

$u = 0 \rightarrow h = \cancel{\frac{u}{\gamma_w}} + y$

$\boxed{h = y} \rightarrow \phi = -ky + cte$

PAS 1 EQUIPOTENTIELLE

PAS 1 LIGNE de COURANT



(b)

SUBSTRATUM ↳ IMPERMEABLE

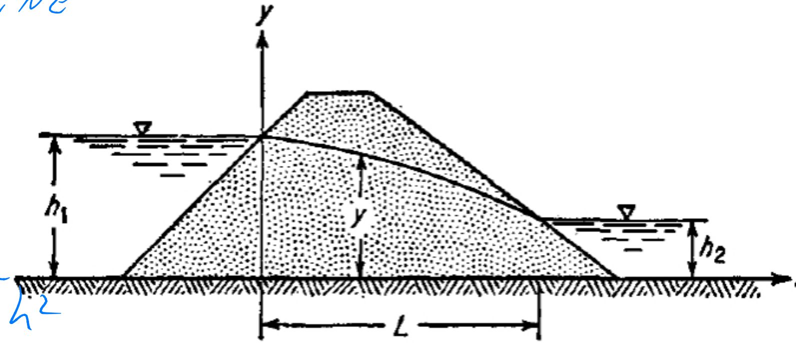
☒ SURFACE LIBRE (Sépare la partie Saturée (bas) avec la partie Non-Saturée (haut))

ex ligne D-G

ligne de courant ($\psi = cte$) ⊕ $u = 0$ (on est à Patm)

↳ $\phi = -ky + cte$

ECOULEMENT NON CONFINÉ



$$Q_x = \int_y q_x = -k\,h\,\frac{\partial h}{\partial x}$$

Eq de CONTINUITÉ

$$\frac{\partial Q_x}{\partial x} = 0 = -k\,\frac{\partial}{\partial x}\,h\frac{\partial h}{\partial x} = -\frac{k}{2}\frac{\partial^2 h^2}{\partial x^2}$$

$$\hookrightarrow \boxed{\frac{\partial^2 h^2}{\partial x^2} = 0} \rightarrow h^2 = Ax + C$$

$$x = 0 \rightarrow h^2 = h_1^2$$

$$x = L \rightarrow h^2 = h_2^2$$

$$h^2 = h_1^2 + \frac{(h_2^2 - h_1^2)\,x}{L}$$

$$\hookrightarrow \left[\, Q_x = -k\,h\,\frac{\partial h}{\partial x} = -\frac{k}{2}\frac{\partial h^2}{\partial x} = -\frac{k}{2L}\left(h_2^2 - h_1^2\right) \right]$$