EWCE 343

Geotechnical and Foundation Engineering

Assalamualaikum

May Allah SWT bestow HIS divine blessings on all of us throughout the year and so on.
Ameen.



EWC 343

Derivation of basic ultimate bearing capacity equation for c-φ soil.

Footing on ϕ-c Soil:

- Footing on a soil with both cohesion c and angle of internal friction ϕ in **Figure 2.**
- A **wedge failure is shown** based on both theoretical considerations and observations of model footing.
- When **wedge displaces in to the ground shown stress block 1**.
- Lateral **pressures are developed along line ag**, which translate **block agf horizontally against wedge afe.**
- **Pressure along vertical line af** are shown by the **stress block** on right side of that line.

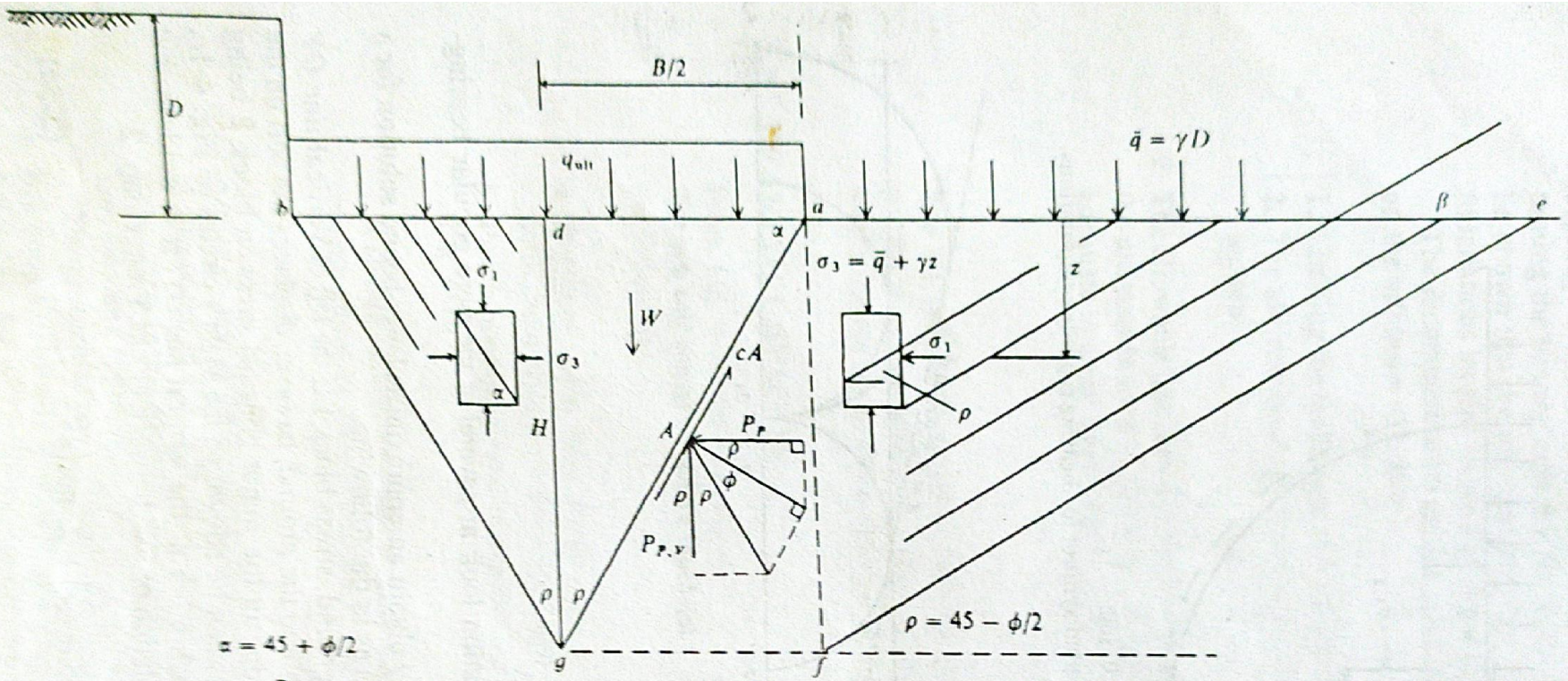


Figure-2: **Footing on ϕ-c Soil**

- It can be shown using Mohr's circle that **wedge agb develops stress slip line** as shown on the small inset stress block, at $\alpha = 45 + \frac{\phi}{2}$ with the horizontal and for footing **with a smooth base** so that **ab is a principle plane.**

- Similarly, **wedge afe** has slip line angle of $\beta = 45 - \frac{\phi}{2}$ that exit at line **ae, also taken as principle plane** at an angle of β.

- From the stress block on the right of vertical line af (of length H), we can compute the **total resisting earth pressure as force P_p** by **integrating the following equation:**

$$\sigma_1 = \sigma_3 \tan^2\left(45 + \frac{\varphi}{2}\right) + 2c \tan\left(45 + \frac{\phi}{2}\right)$$

- $P_p = \int_0^H \sigma_1 (dz) = \int_0^H (\gamma z + q) \tan^2 (45 + \frac{\varphi}{2}) + 2c \tan (45 + \frac{\varphi}{2})\} dz$ (stress block-2)

- Using the definition of K_p and integrating, we get,

$$P_p = \frac{\gamma H^2}{2} . K_p + qH . K_p + 2cH . \sqrt{K_p}$$

Where, $K_p = \tan^2 (45 + \frac{\varphi}{2})$

- **To find q_{ult},** one must sum of forces in the vertical direction for the **half-wedge adg** of unit width using forces shown:

Footing pressure wedge wt. Cohesion Lateral pressure

$$q_{ult} \text{ X } \frac{B}{2} + \frac{1}{2}\frac{B}{2} \text{ H } (\gamma) + \text{cA cos } \beta - \frac{P_p}{\text{Sin } \beta Cos\ \varphi} = 0$$

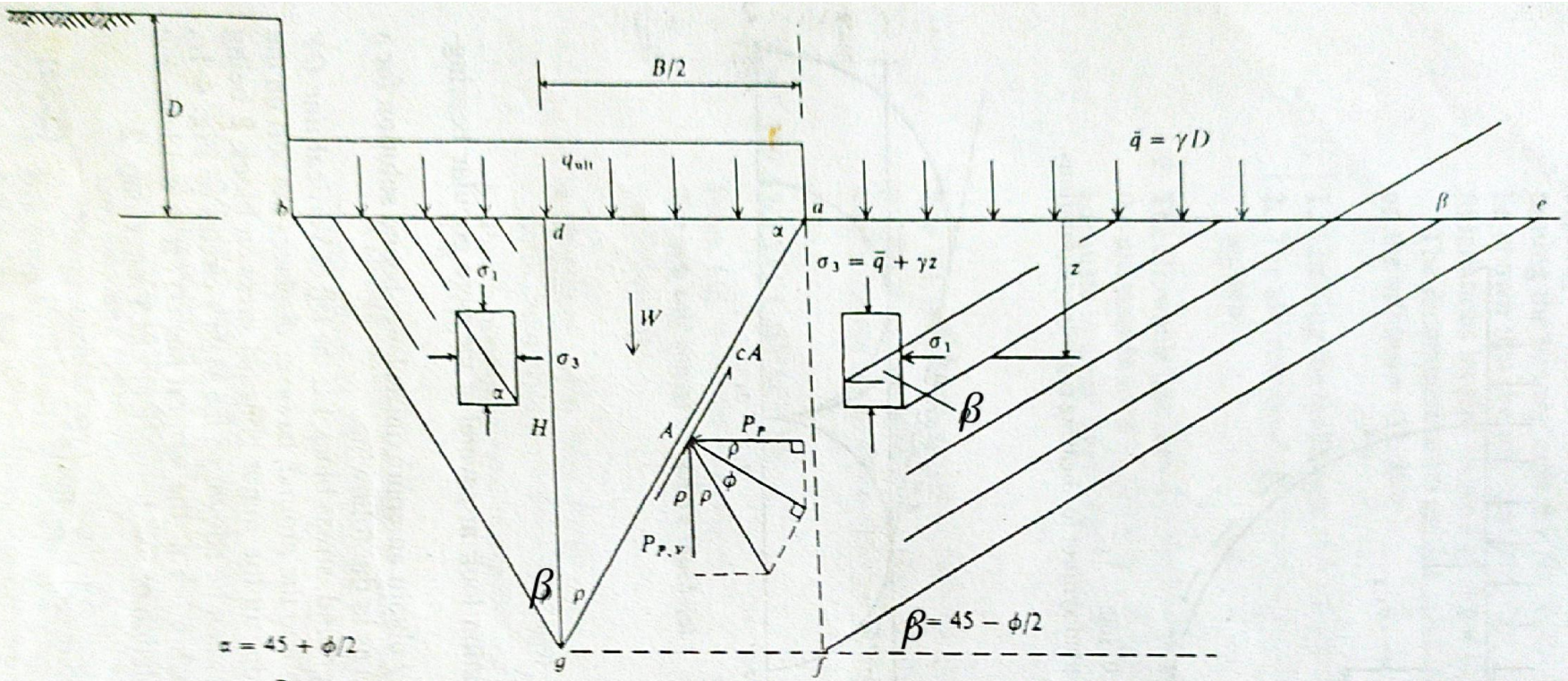


Figure-2: **Footing on ϕ-c Soil**

- On **substituting of values of H and A**, we get,

$$H = \frac{B}{2}\tan\alpha \qquad \text{and} \qquad A = \frac{B}{2\cos\alpha}$$

$$q_{ult} = c\left[\frac{2K_p}{Cos\ \varphi} + \sqrt{K_p}\right] + q\,\frac{\sqrt{K_{p.K_p}}}{Cos\ \varphi} + \frac{\gamma B}{4}\left[\frac{{K_p}^2}{Cos\ \varphi} - \sqrt{K_p}\right]$$

- **Replacing the c, q and γB multipliers** with **N factors**, we can write the equation in the commonly used format as

$$q_{ult} = \mathrm{c}\, N_c + \bar{\mathrm{q}}\, N_q + \gamma \mathrm{B}\, N_\gamma$$

- Derivations are the **only to illustrate the problems** in defining the ultimate bearing capacity of soil.

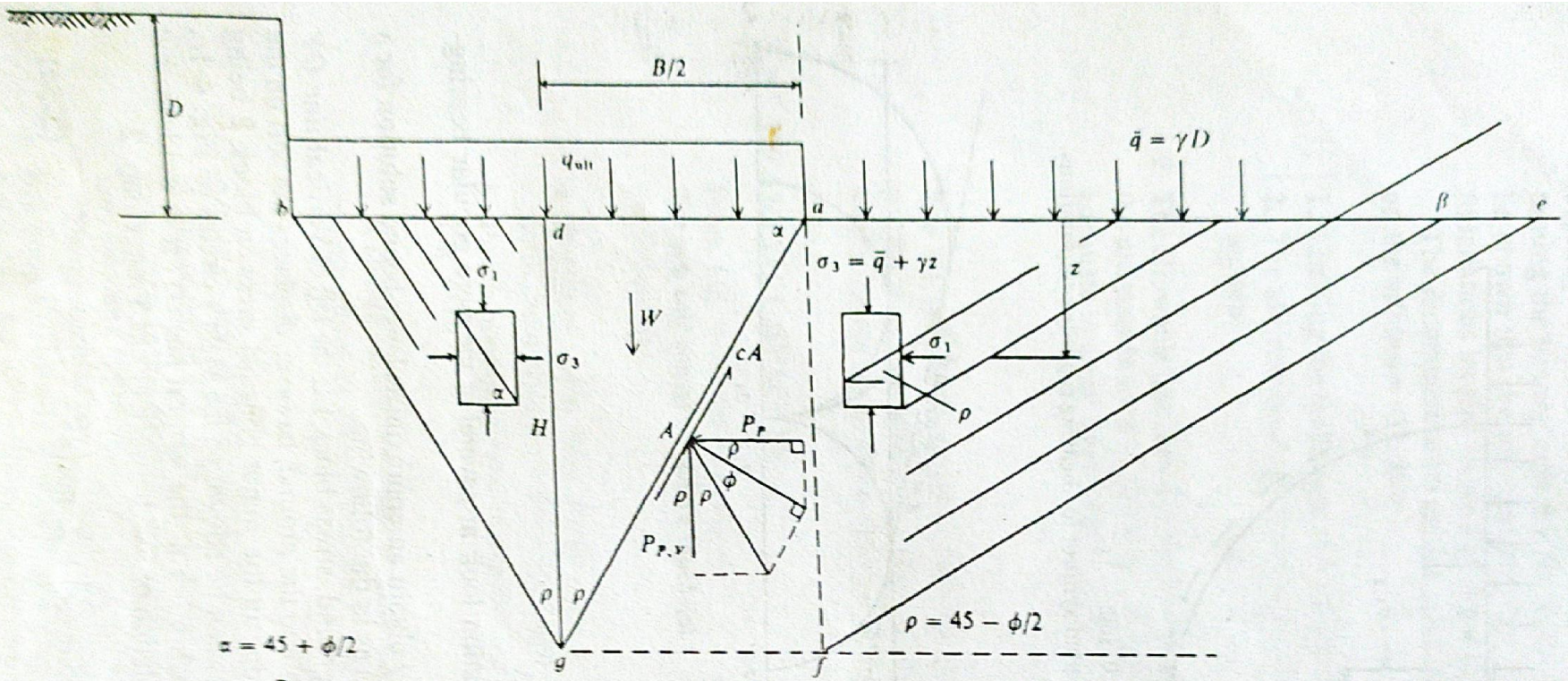


Figure-2: **Footing on ϕ-c Soil**

Reasons for underestimating q_{ult} substantially for φ –c Soil:

- **Zone afg** is neglected.
- **Footing interface** is usually rough and contributes a roughness effect.
- **Shape of block agfe is a** poorly defined the zone, resisting the wedge movement into the soil.
- **Solution is for a unit width strip**, across a very long footing, so it needs to be adjusted for round, square or finite length footing (ie it needs a shape factor).
- **Shear resistance from plane ae**, to the ground surface has been neglected, requiring some sorts of adjustment (ie. a depth factor).
- **Other factors** will be needed if q_{ult} is inclined from the vertical (ie inclination factors).

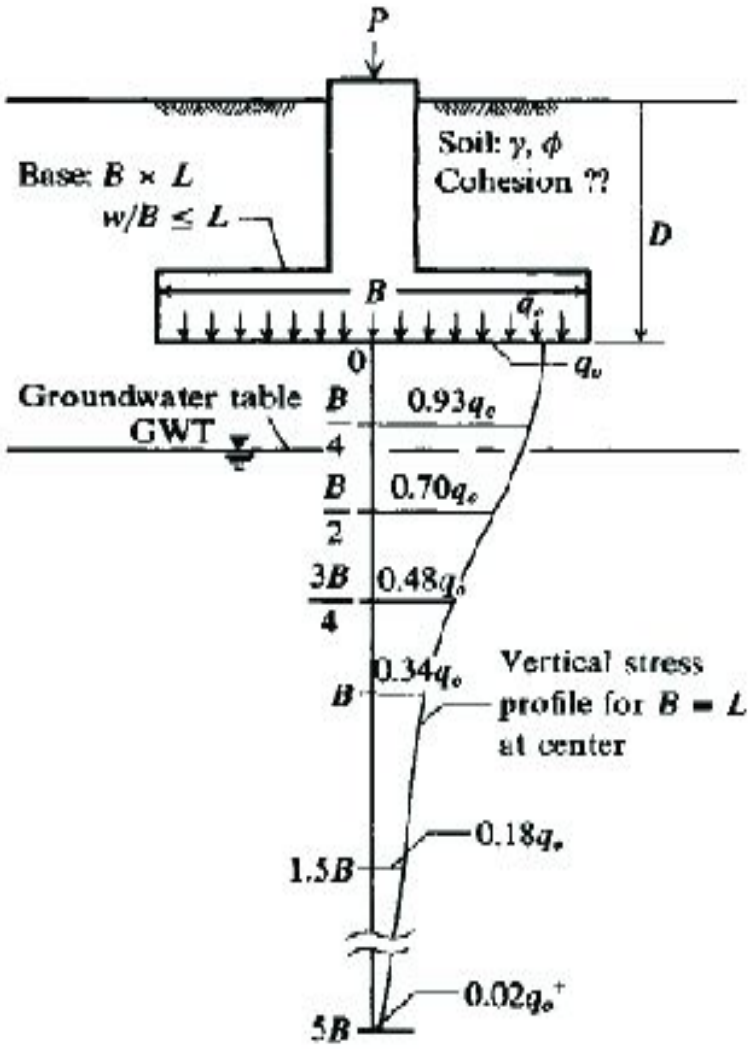
Minimum Requirements for designing foundation:

- Locate the **site and position** the loads.
- Physically **inspect the site** for any geological and other evidence which may indicate design problems.
- Field exploration, supplementary field tests and lab tests.
- Determination of design parameters.
- Design the foundation by using design parameters.

Points to be kept in mind while designing foundation basing on the design parameters:

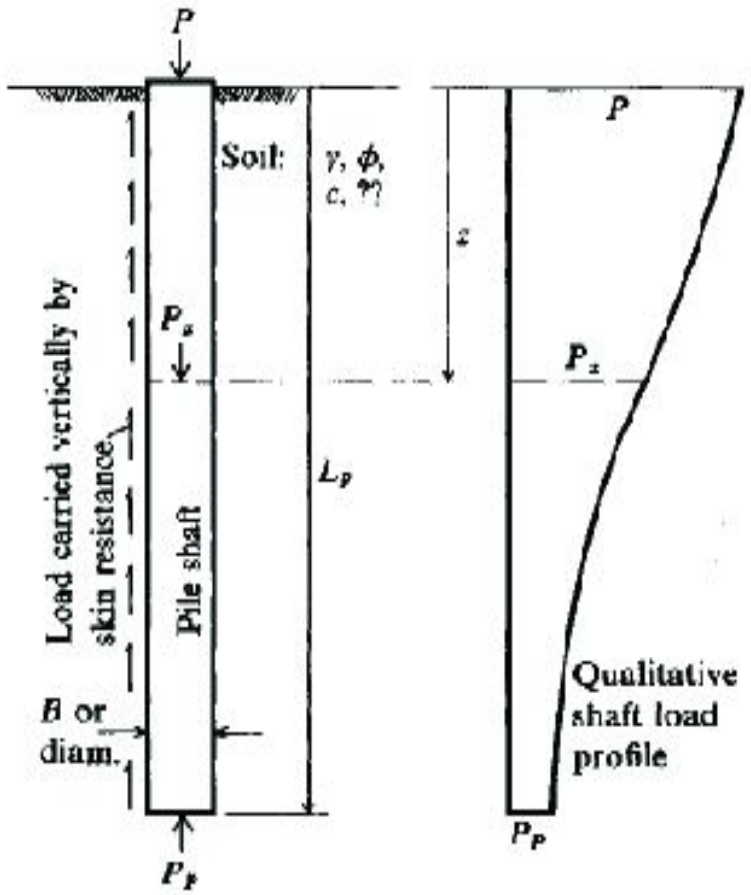
- Foundation to be **designed economically**.
- Able to be **built up with** available **construction materials and personals.**
- **Take into account practical construction tolerance** and **local construction practices.**
- **Overdesign** to be avoided.
- **Risks** to be at tolerable limits.

Influence depth for base contact pressure of Spread Foundation:



(a) Spread foundation. Base contact pressure

$$q_o = \frac{P}{BL} \text{ (units of kPa, usually)}$$



(b) Pile foundation. P_p = tip, point, or pile base load (units of kN)

Influence depth for base contact pressure of Spread Foundation:

- Normally at depth **5B**, below critical depth stress is less than **$0.02q_0$ (2%).**
- At depth B it is 0.**$34q_0$ (34%)**
- B is normally in between **0.3m to 3.0m (10 times, ratio is 1:10)**.
- For **B=0.3m**, influence critical depth is **(5B=5x0.3) 1.5m**.
- **For B=1.5m, influence critical depth is 15m**, ratio is usually **1:10**.
- So, for possible soil condition **below 2.0m**, would have considerable influence on the design of wider footing.

Thanks