SOIL STRESS

*TOTAL STRESS, σ

*PORE PRESSURE, u

*EFFECTIVE STRESS, σ'

Prepared by:
Dr. Hetty

STRESS

$$\sigma\ (kN/m^2) = \gamma.z$$

where:

γ = unit weight of soil (kN/m^3)

z = depth / thickness from ground surface (m)

TOTAL NORMAL STRESS

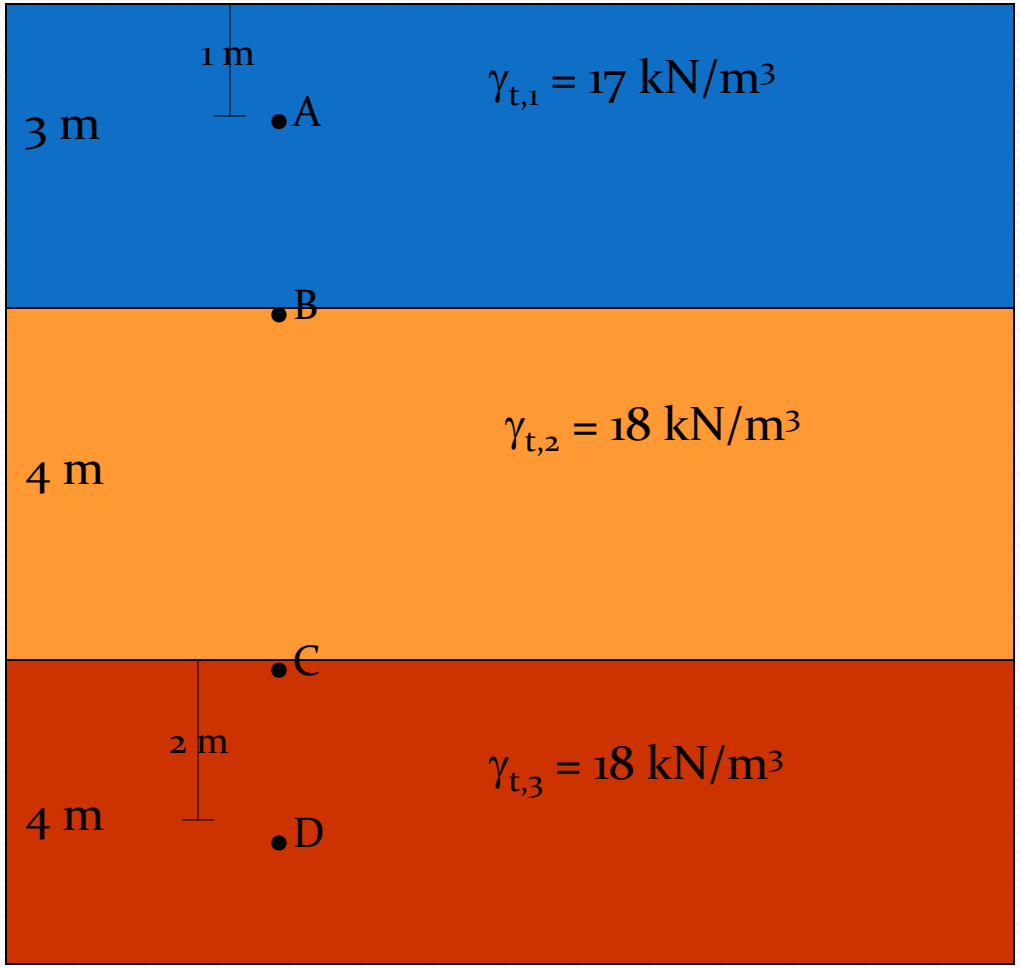
- Generated by the mass in the soil body, calculated by sum up the unit weight of all the material (soil solids + water) multiplied by soil thickness or depth.
- Denoted as σ, σ_v, Po
- The unit weight of soil is in natural condition and the water influence is ignored.
- Total stress increases with depth and with unit weight: Vertical total stress at depth z

$$\sigma = \sum \gamma_t . z$$

z = The depth of point

EXAMPLE 1 : Total stress in multi-layered in soil

The total stress at depth z (i.e. Point D) is the sum of the weights of soil in each layer thickness above.



$\sigma_A = \gamma_{t,1} \times 1\ m$

$= 17\ kN/m^2$

$\sigma_B = \gamma_{t,1} \times 3\ m$

$= 51\ kN/m^2$

$\sigma_C = \gamma_{t,1} \times 3\ m + \gamma_{t,2} \times 4\ m$

$= 123\ kN/m^2$

$\sigma_D = \gamma_{t,1} \times 3\ m + \gamma_{t,2} \times 4\ m + \gamma_{t,3} \times 2\ m$

$= 159\ kN/m^2$

Pore water pressure (u)

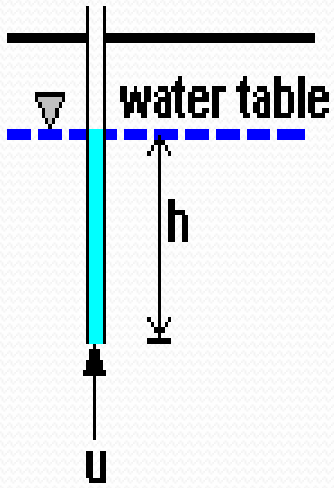
Under hydrostatic conditions (no water flow) the pore pressure at a given point is given by the **hydrostatic pressure:**

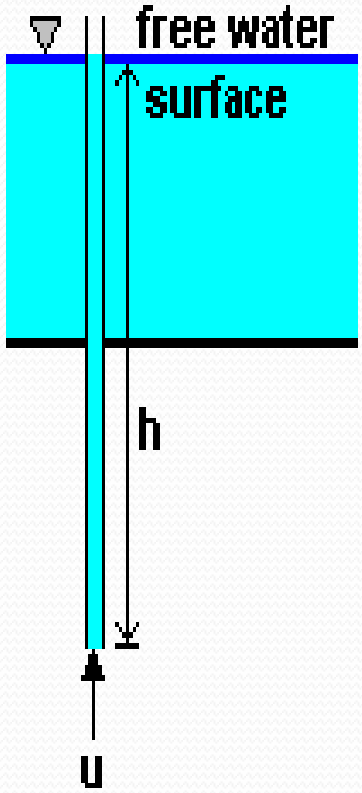
$$u = \gamma_w . h_w$$

Where

γ_w = unit weight of water ($9.81 kN/m^3 \approx 10 kN/m^3$)

h_w = depth below water table or overlying water surface





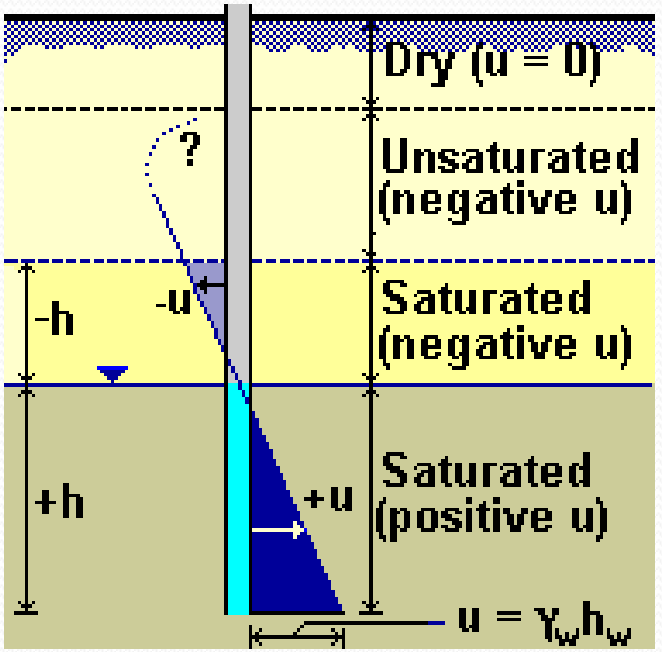
Negative pore pressure

- Below the water table, pore pressures are **positive**.

- In dry soil, the pore pressure is **zero**.

- Above the water table, when the soil is saturated, pore pressure will be **negative**.

$u = -(\gamma_w . h_w)$

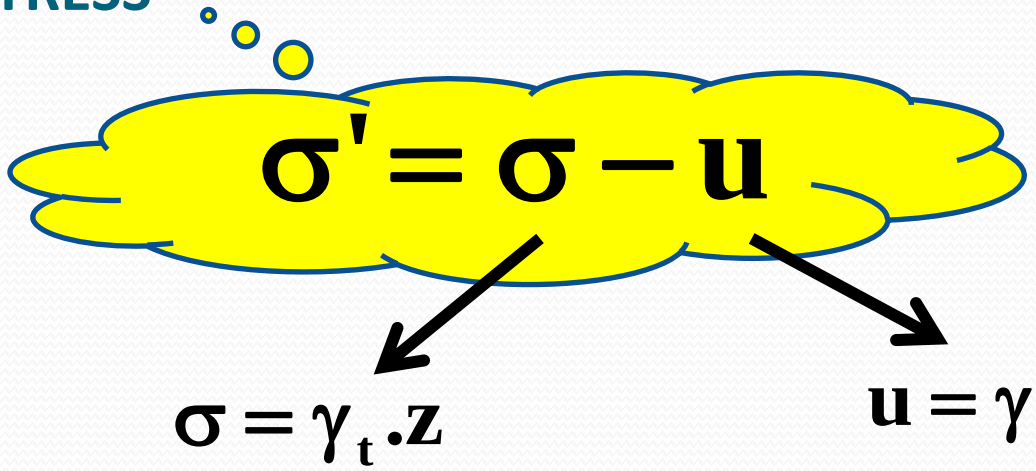


EFFECTIVE STRESS

- Defined as soil stress which not influenced by water pressure in soil body.
- Published first time by Terzaghi at 1923 base on the experimental result
- Applied to saturated soil and has a relationship with two type of stress i.e.:
  - Total Normal Stress (σ)
  - Pore Water Pressure (u)
- Effective stress formula

$$\sigma' = \sigma - u$$

EFFECTIVE STRESS



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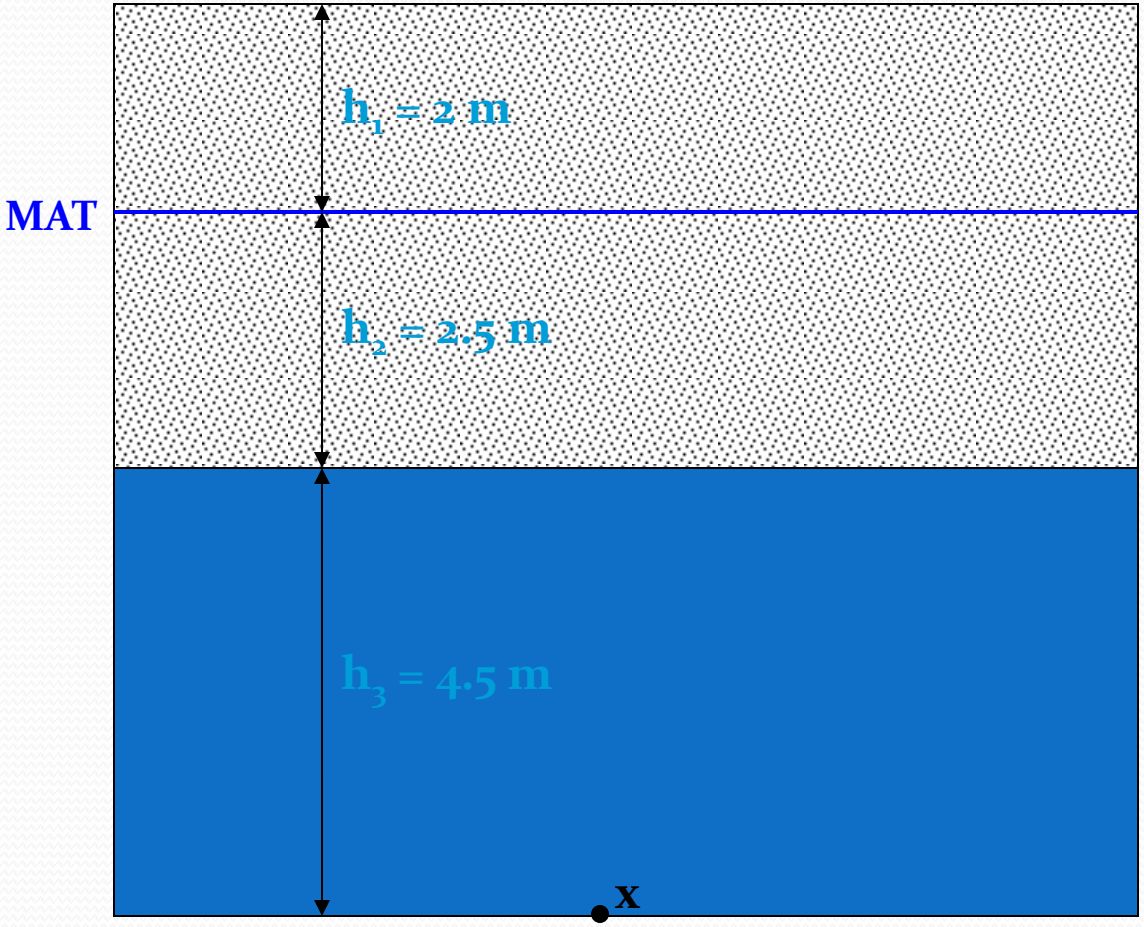
$$\sigma' = (\gamma_t - \gamma_w).z = \gamma'.z$$

EXAMPLE 2



Sand

γ_{sat} = 18.0 kN/m³

γ_{d} = 13.1 kN/m³

Clay

γ_{sat} = 19.80 kN/m³

EXAMPLE

- Total Stress

  $\sigma = \gamma_{d,1} \cdot h_1 + \gamma_{t,1} \cdot h_2 + \gamma_{t,2} \cdot h_3$

  $\sigma = 13.1 \cdot 2 + 18 \cdot 2.5 + 19.8 \cdot 4.5$

  $= 160.3\ kN/m^2$

- Pore Water Pressure

  $u = \gamma_w \cdot (h_2 + h_3)$

  $u = 10 \cdot 7$

  $= 70\ kN/m^2$

- Effective Stress

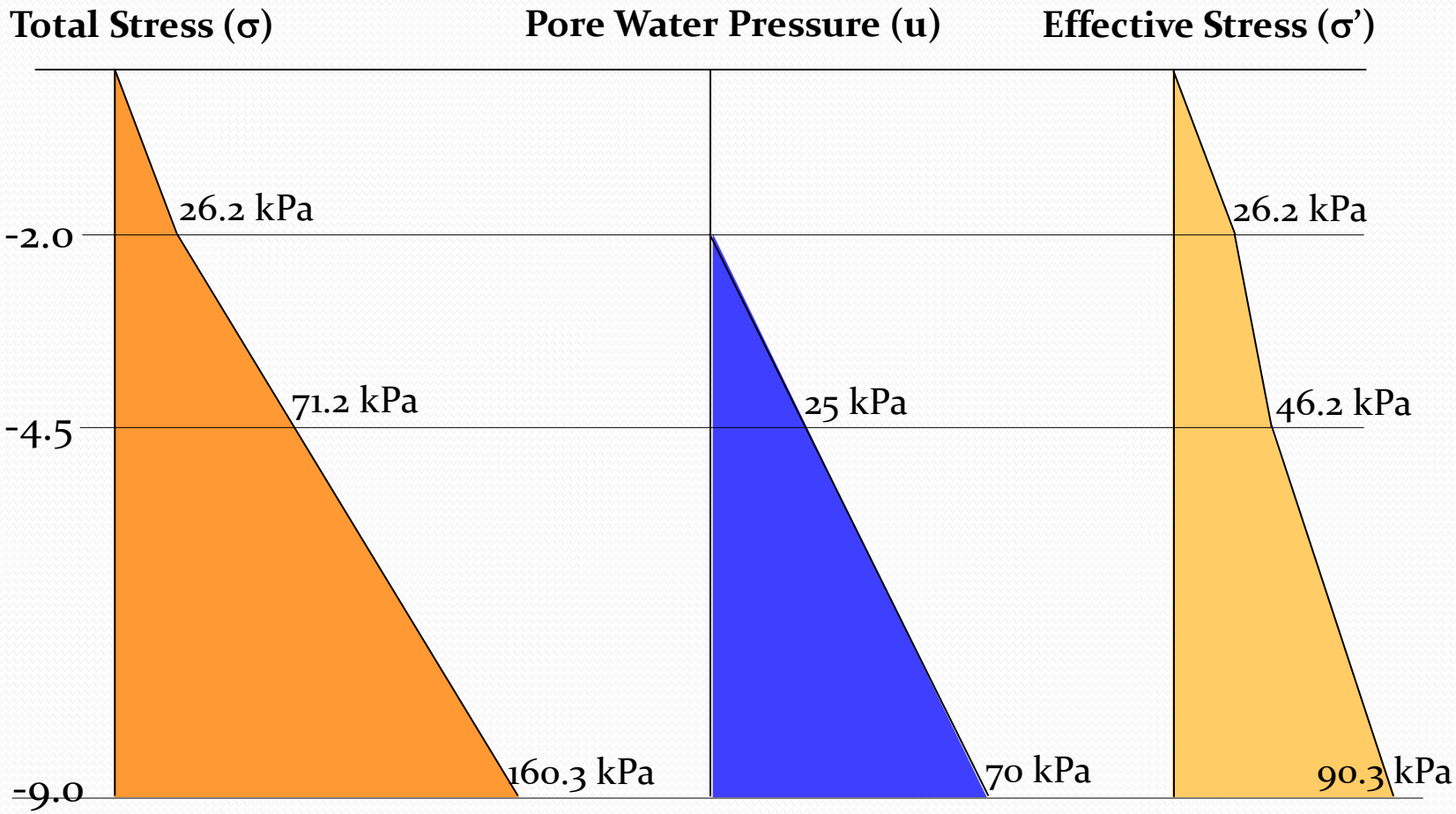
  $\sigma' = \sigma - u = 90.3\ kN/m^2$

$$\sigma' = \gamma_{d,1} \cdot h_1 + (\gamma_{t,2} - \gamma_w) \cdot h_2 + (\gamma_{t,2} - \gamma_w) \cdot h_3$$

$$\sigma' = 13.1 \cdot 2 + (18\text{-}10) \cdot 2.5 + (19{,}8\text{-}10) \cdot 4.5$$

$$= 90.3\ kN/m^2$$

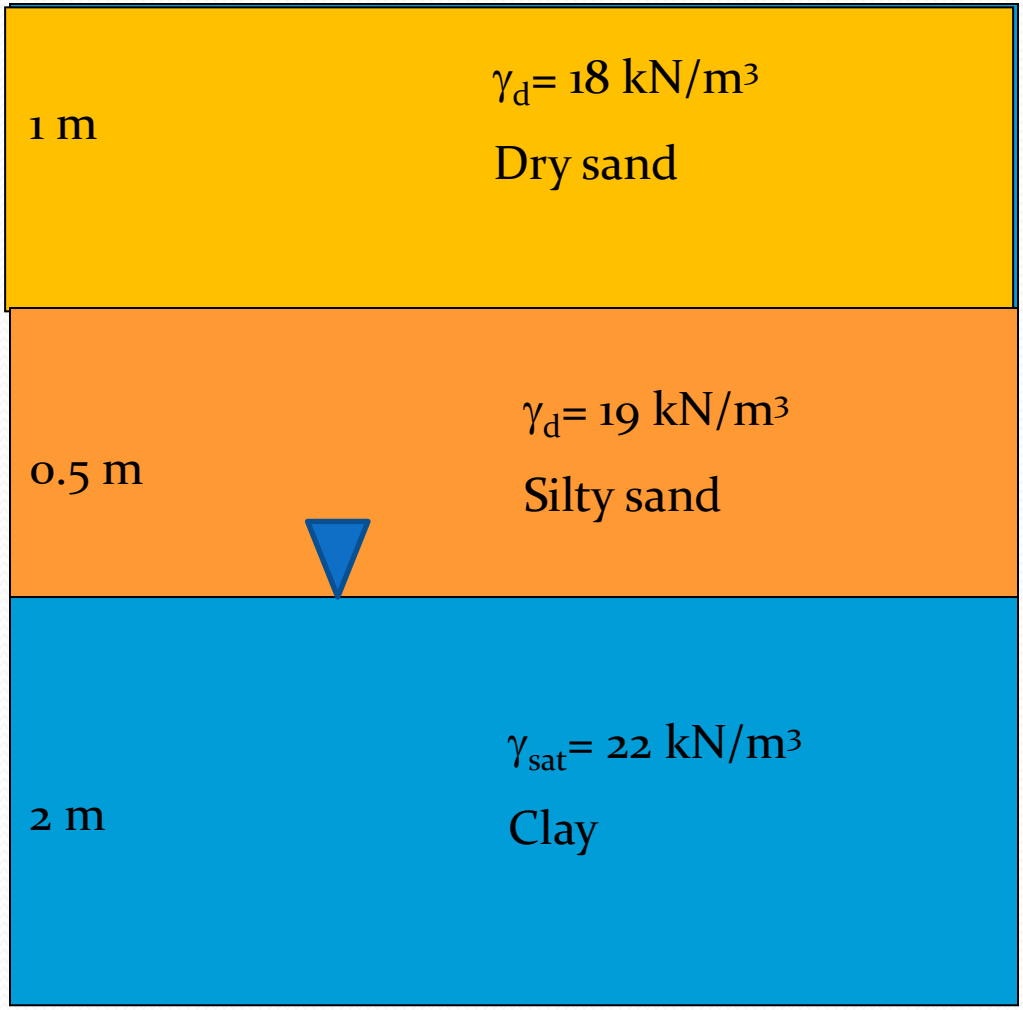
EXAMPLE



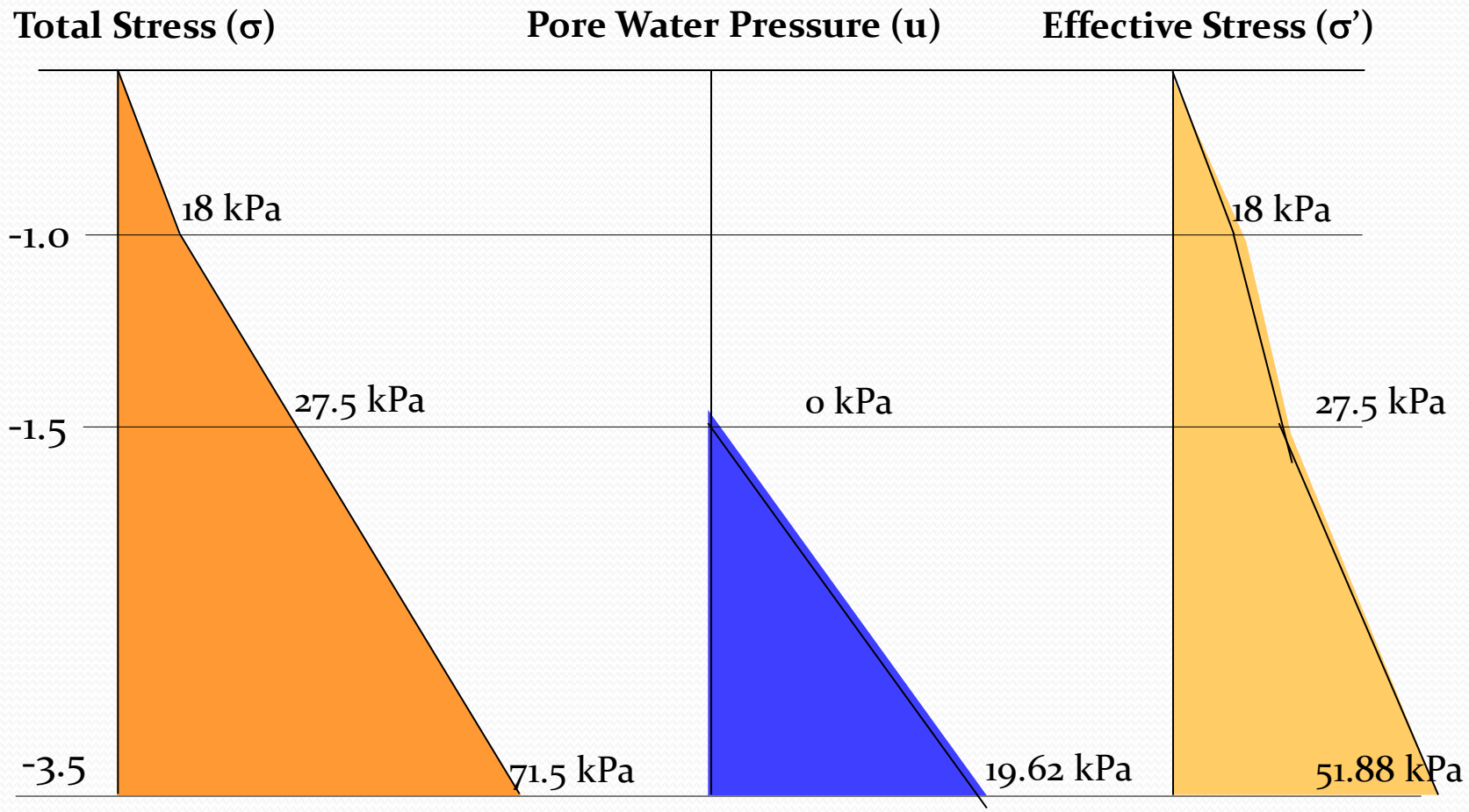
Profile of Vertical Stress / Stress distribution Diagram

EXAMPLE 3

For the soil profile shown here, plot the stress distribution diagram including total stress, pore pressure and effective stress



EXAMPLE 3 (answer)



Profile of Vertical Stress / Stress distribution Diagram