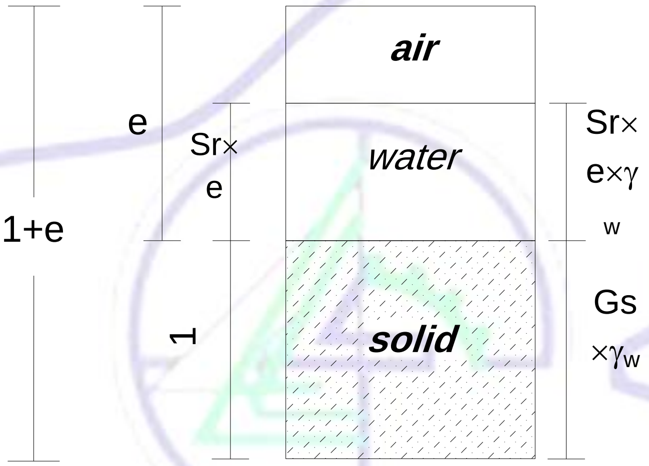
## 5-1 Derivation of Phase Relations

Bulk unit weight of rock and/or soil:

$$\gamma = \left(\frac{G_s + S_r \times e}{1 + e}\right)\gamma_w$$

Let consider Phase Diagrams as shown in figure (5-1) below:

For purpose of derivation, assume $V_s$=1, thus and from phase diagram, we can conclude:




$$e = \frac{V_v}{V_s}$$

$\therefore$ for $V_s$=1 $\Rightarrow$ e=$V_v$

$V_t = V_s + V_v = 1+e$

$$S_r = \frac{V_w}{V_s}$$

$$e = \frac{V_v}{V_s}$$

$$\therefore S_r \times e = \frac{V_w}{V_v} \times \frac{V_v}{V_s}$$

$$\therefore S_r \times e = V_w$$

$$W_w = V_w \times \gamma_w = S_r.e.\gamma_w$$

$$W_s = V_s \times \gamma_s = 1 \times \gamma_s$$

$$W_s = G_s.\gamma_w$$

Since the bulk unit weight of rock is :

$$\gamma = \frac{W}{V_t} = \frac{W_s + W_w}{V_t}$$

$$\therefore \gamma = \frac{G_s.\gamma_w + S_r.e.\gamma_w}{1+e}$$

$$\boxed{\gamma = \left(\frac{G_s + S_r.e}{1+e}\right).\gamma_w}$$

**Example 5-1:**

A sandstone rock specimen consist of quartiz and feldspar. When the rock is saturated with water, it's weight is 21.4 N. While the dry weight is 20.3 N, and the spesific weight of rock is 2.63. Determine:

1- porosity of rock.

2- dry unit weight.

3- moist unit weight.

**Solution:**

$$n = \frac{\omega G_s}{1+\omega G_s}$$

$$\omega = \frac{W_w}{W_s} = \frac{W_{sat.} - W_{dry}}{W_s} = \frac{21.4 - 20.3}{20.3} = 0.0541 = 5.41\ \%$$

$$n = \frac{0.0541 \times 2.63}{1+0.135} = 0.1253 = 12.53\ \%$$

$$\gamma_{dry} = \frac{G_s}{1+e}\gamma_w$$

Since $[n = \frac{e}{1+e}]$

$$\therefore e = \frac{n}{1-n}$$

$$e = \frac{0.1253}{1-0.1253} = 0.1432 = 14.32\ \%$$

$$\gamma_{dry} = \frac{2.63}{1+0.1432} \times 9.81 = 22.56\ kN/m^3$$

$$\gamma_{dry} = \frac{\gamma_{wet}}{1+\omega}$$

$$22.56 = \frac{\gamma_{wet}}{1+0.0541}$$

$$\gamma_{wet} = 22.56(1+0.0541)$$

$$\gamma_{wet} = 23.78\frac{kN}{m^3}$$