3-1 Physical Properties of Rock Material الخصائص الفيزيائية للصخور

Rock material is the integral rock portion. The strength of rocks depends on the physical and mechanical properties for rock materials.

يعتمد سلوك الصخور تحت ظروف معينة على الخواص الفيزيائية والهندسية(الميكانيكية) للمواد المكونة لها، وهنالك العديد من التصنيفات لخواص الصخور منها:

☒ Physical properties (index-properties).

☒ Mechanical properties (strength properties).

[A] Physical Properties(Index-Properties).

The most important physical properties of rocks can be summarized by the following:

1- Density(الكثافة):

Density is a measure مقياس of mass per unit of volume. Density of rock material various متنوعة, and often related to the porosity المسامية of the rock. Its measured by (gm/cm^3,kg/m^3), most rocks near the earth surface have density between [1.5-3.0g/cm^3].Density represent the bulk density الكثافة الكلية, its common physical properties and influenced by تتأثر بـ:

i. the specific gravity of the composition minerals الوزن النوعي للمعادن المكونة للصخور

ii. The compaction of the minerals الدمك (الرص) للمعادن المكونة للصخر. However, most rocks are well compacted and then have specific gravity between [2.5 up to 2.8].

iii. Density is used to estimate overburden stress تستخدم الكثافة لحساب ضغط التثقيل.

- Expressed by the symbol (ρ) يعبر عنها بالرمز:

$$\rho = \frac{M}{V}$$

In which حيث ان:

M = mass of rock material per unit volume (kg).

V = volume of rock mass (m^3).

2-Unit weight (وحدة الوزن):

The ratio between the weight of rock to its volume, denoted يشار لها بالرمز by symbol (γ), measured by units تقاس بوحدات(N/m^3).

$$\gamma = \frac{W}{V}$$

$$\gamma = \frac{W}{V} = \frac{M.g}{V} = \frac{M}{V}g = \rho g$$

In which;

g= gravitational acceleration التعجيل الارضي=9.81 m/sec^2.

3-Spesific weight (الوزن النوعي):

The ratio between rock density or (unit weight) to the water density or(water unit weight). It's important engineering properties and denoted by (G_s), its dimensionless quantity خالية من الوحدات.

$$G_s = \frac{\rho_{rock}}{\rho_w} (OR) \frac{\gamma_{rock}}{\gamma_w}$$

ρ_w=**1000 kg/m^3**

$\gamma_w=\rho_w g= 1000 \times 9.81=9810 \approx 9800$ **N/m^3 (or) 9.8 kN/m^3.**

EXAMPL1:

A rock mass of dimensions (85×79×43.5 cm), and have a mass of (950 kg). Find the specific gravity of rock.

Solution:

$V_{Mass} = \frac{(85\times79\times43.5)}{100^3} = 0.2921$ m^3(volume rock mass)

$\rho = \frac{M}{V} = \frac{950}{0.2921} = 3252.31$ kg/m^3

$G_s = \frac{\rho_{rock}}{\rho_w} = \frac{3252.31}{1000} = \underline{3.25}$

4-Porosity(المسامية):

Porosity describes how densely the material is packed. It is the percentage ratio of the non-solid volume(volume of voids) to the total volume of material. Porosity therefore is a fraction between 0 and 1.The value is typically ranging from less than 0.01 for solid granite to up to 0.5 for porous sandstone.

المسامية وصف لطريقة ترتيب ورصف الجزء الصلب(المعدني) من تركيب الصخور ضمن حجم معين ، وهي النسبة المئوية بين حجم الفراغات الى الحجم الكلي للعينة الصخرية. لذا المسامية هي جزء بين 0 و 1 وهذه القيمة عادة ما تتراوح بين اقل من 0.01 للغرانيت الصلب لتصل الى 0.5 للحجر الرملي المسامي.

Density and porosity often related to the strength of rock material غالبا ما ترتبط قوة الصخور بكل من الكثافة والمسامية. A low density and high porosity rock usually has low strength الصخور ذات الكثافة القليلة والمسامية العالية تكون صخور ضعيفة. Porosity is one of the governing factors for the permeabilityالنفاذية. Porosity provides the void for water to flow

through in a rock material. High porosity therefore naturally leads to high permeabilityالمسامية العالية تعني نفاذية عالية.

يرمز للمسامية بالرمز ($\boldsymbol{n}$)وتكون اما نسبة مئوية او كسر.

$$\boldsymbol{n = \frac{V_v}{V} \times 100}$$

In which;

V_v = volume of voids حجم المسامات

V = total volume of rock sample الحجم الكلي للعينة الصخرية

$V=V_v+ V_s$

V_s=volume of solid (mineral).

$V_s=V_g$ =volume of mineral grains of rock(حجم الحبيبات المعدنية).

The density of mineral grains of rock is denoted by ($\boldsymbol{\rho_g}$) and expressed by:

$$\boldsymbol{\rho_g = \frac{M_g}{V_g}}$$

In which;

M_g=mass of mineral grains

V_g=volume of mineral grains.

$V_g=V-V_v$

Since$[\ V_v=nV]$

$\therefore\ V_g=V-nV=V(1-n)$

$$\therefore \boldsymbol{\rho_g = \frac{M_g}{V(1-n)}}$$

Generally;

$$\boxed{\boldsymbol{\rho_g = \frac{M}{V(1-n)}}}$$

$$\boldsymbol{\gamma_g = \frac{\gamma}{V(1-n)}}$$

5-Void Ratio (نسبة الفراغات):

The ratio of the volume of the voids to the volume of the solids (mineral grains), denoted by ($\boldsymbol{e}$) and expressed by:

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

نسبة الفراغات (او المسامات) هي النسبة بين حجم الفراغات الى حجم المادة الصلبة(الجزء المعدني للصخور).

$V=V_v+V_s$

$\therefore V_s=V-V_v$

$$\boldsymbol{\therefore e = \frac{V_v}{V - V_v}}$$

and $\boldsymbol{n = \frac{V_v}{V}} \Rightarrow V_v=nV$

$$\boldsymbol{e = \frac{nV}{V - nV}}$$

$$\boldsymbol{\therefore e = \frac{nV}{V(1-n)}}$$

$$\boxed{\boldsymbol{e = \frac{n}{1-n}}}$$

EXAMPL2:

A sandstone rock have volume of (0.885 m^3) and mass of (1750kg), when the rock is well crushed, its volume is reduced to(0.584 m^3). Find the following:

1- porosity of rock($\boldsymbol{n}$)

2- density mineral grains($\boldsymbol{\rho_g}$)

Solution:

$V=V_v+V_s$ or $[V=V_v+V_g]$

$V_v=V-V_s$

$V_v=0.885-0.584=0.301\ m^3$

$$n=\frac{V_v}{V}\times 100$$

$$n=\frac{0.301}{0.885}\times 100=34.011$$

Suppose that the rock density did not change after the crushing process, thus:

$$\rho_g=\frac{M_g}{V_g}$$

$$\rho_g=\frac{1750}{0.584}=2996.575\ kg/m^3$$

$\rho_g \approx 3000 kg/m^3$ or (3 g/cm^3)

6-Water Content (المحتوى المائي):

Water content is a measure indicating the amount of water the rock material contains. It issimply the ratio of the weight of water to the total weight of the rock material. Denoted by ($\boldsymbol{\omega}$), and expressed by:

$$\omega = \frac{W_w}{W_s} \times 100 = \frac{W - W_s}{W_s} \times 100$$

In which;

W=total weight of rock الوزن الكلي للصخرة

W_w=weight of water وزن الماء

W_s= weight of solid (mineral part)وزن المادة الصلبة.

7-Degree of Saturation (درجة التشبع):

The degree of saturation, S_r, refers to the relative volume of water, V_w, in the voids, V_v, and is expressed as a percentage:

$$S_r = \frac{V_w}{V_v} \times 100$$

النسبة بين حجم الماء الذي يملأ الفراغات الى الحجم الكلي لهذه الفراغات ويعبر عنها كنسبة مئوية، فالصخور التي تمتاز بمسامية عالية يكون لها درجة تشبع اعلى ونجدها تحت منسوب المياه الجوفية(ground water table).