PHYSICAL PROPERTIES

ROCK

By

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1. INTRODUCTION

Information collected by geologists and engineering geologists is in general not sufficient to predict the engineering behavior of rocks and rock masses. Tests need to be conducted to assess the response of rocks under a wide variety of disturbances such as static and dynamic loading, seepage and gravity and the effect of atmospheric conditions and applied temperatures. In general, rock and rock mass properties can be divided into five groups:

1. physical properties (durability, hardness, porosity, etc.),
2. mechanical properties (deformability, strength),
3. hydraulic properties (permeability, storativity),
4. thermal properties (thermal expansion, conductivity), and
5. *in situ* stresses.

This set of notes focuses on physical properties such as weathering potential, slaking potential, swelling potential, hardness, abrasiveness, and other properties such as porosity, density, water content, etc. Most of those properties are intact rock properties.

2. WEATHERING AND SLAKING

When exposed to atmospheric conditions, rocks slowly break down. This process is called weathering and can be separated into *mechanical* (also called physical) weathering and *chemical* weathering.

Mechanical Weathering

Mechanical weathering causes disintegration of rocks into smaller pieces by exfoliation or decrepitation (slaking). The chemical composition of the parent rock is not or is only slightly altered. Mechanical weathering can result from the action of agents such as frost action, salt crystallization, temperature changes (freezing and thawing), moisture changes (cycles of wetting and drying), wind, glaciers, streams, unloading of rock masses (sheet jointing), and biogenic processes (plants, animals, etc.).

A example of mechanical weathering is the one associated with the rapid cooling and heating of rocks in desert areas. Temperature gradients are large enough to crack rocks.

2.1 Chemical Weathering

This type of weathering creates new minerals in place of the ones it destroys in the parent rock. As rocks are exposed to atmospheric conditions at or near the ground surface, they react with components of the atmosphere to form new minerals. The most important atmospheric reactants are oxygen, carbon dioxide, and water. In polluted air, other reactants are available (acid rain problems associated with the release of sulfuric acid from coal-fired power plants, sulfur dioxide and smoke emissions, nitrogen oxides from vehicle exhaust).In general, chemical weathering reaction are exothermic and cause volume increases.

Solution is a reaction whereby a mineral completely dissolves during weathering. This type of reaction depends on the solubility of the rock minerals.

Hydrolysis is the reaction between acidic weathering solutions and many of the silicate minerals.

Hydration corresponds to the penetration of water into the lattice structure of minerals.

Oxidation corresponds to the reaction of free oxygen with metallic elements. This reaction is familiar to everyone as rust.

2.2 Slaking

The *slake durability test,* is a test intended to assess the resistance offered by a rock sample to weakening and disintegration when subject to one (or several) cycle(s) of drying and wetting. It is a standardized measurement of the weight loss of rock lumps when repeatedly rotated through an air water interface.

The slake durability test apparatus consists of two drums 100 mm long and 140 mm in diameter, containing about 500g of rocks (10 lumps) in each drum. Sieve mesh forms the walls of the drums with openings of 2 mm. .{You are reading it on mineportal.in}The drums rotate at a speed of 20 rpm for a period of 10 minutes in a water bath. The rock in the drums are subject to different cycles of wetting in the bath and drying in the oven.

Let D be the mass of the empty dry drum. The initial dry mass of rock plus drum is defined as
A. After one cycle of wetting and drying, the new dry mass of the drum and the rock is B. The slake durability index I_{d1} is the percent of rock retained and is equal to

$$I_{d1} = \frac{(B-D)}{(A-D)}.100\% \qquad (1)$$

The test is repeated a second time and C is the final dry mass of the drum and remaining rock.

The slake durability index I_{d2} is then equal to

$$I_{d2} = \frac{(C-D)}{(A-D)}.100\% \quad (2)$$

3. SWELLING POTENTIAL

Chemical weathering reactions are usually accompanied with an increase in volume .The term swelling rock (or soil) implies not only the tendency of a material to increase in volume when water is available but also to decrease in volume and shrink if water is removed. Whether a soil or rock with high swelling potential will actually exhibit swelling characteristics depends on several factors: (1) the difference between the field moisture content at the time of construction and the final equilibrium, moisture content associated with the completed structure (2) the degree of compaction with more compaction favor swelling as moisture becomes available, (3) the final stress to which the material will be subjected after construction is complete.

4. HARDNESS AND ABRASIVENESS

Knowledge of the hardness and abrasiveness of rock is very important when predicting rock drillability, cuttability, borability and tunnel boring machine advance rates. These two physical properties depend to a great extent on the mineralogical composition of the rock and the type and the degree of cementation of the mineral grains

Rock hardness can be expressed using the Mohrs scale used for minerals or can be measured (in a non-destructive way) using the *Schmidt Rebound Hammer* or the *Shore Scleroscope*.

The Schmidt Rebound Hammer

The plunger of the hammer is pressed against the rock surface . A spring driven mass within the housing of the hammer is released, strikes the plunger and rebounds, a pointer on a scale recording the amount of rebound as a percentage of the initial spring compression. The rebound number, also known as the *Schmidt Rebound Index*, R, is read by pressing a locking mechanism . In general, 10 readings are made. The value of R is higher for harder and stronger rocks which absorb less of the impact energy. Tests can be conducted in the laboratory on rock specimens or in the field on rock surfaces away from major discontinuities. In all cases, measurements must be made at right angles to the surfaces. The Schmidt hammer is calibrated for horizontal impact direction, i.e for testing vertical surfaces. .{You are reading it on mineportal.in}When using it on horizontal or inclined surfaces, correction factors must be applied. Empirical equations have been suggested to relate R to the unconfined compressive strength.

The Shore Scleroscope,is used to determine dynamic hardness where indentation is done by a rapidly moving indenter.

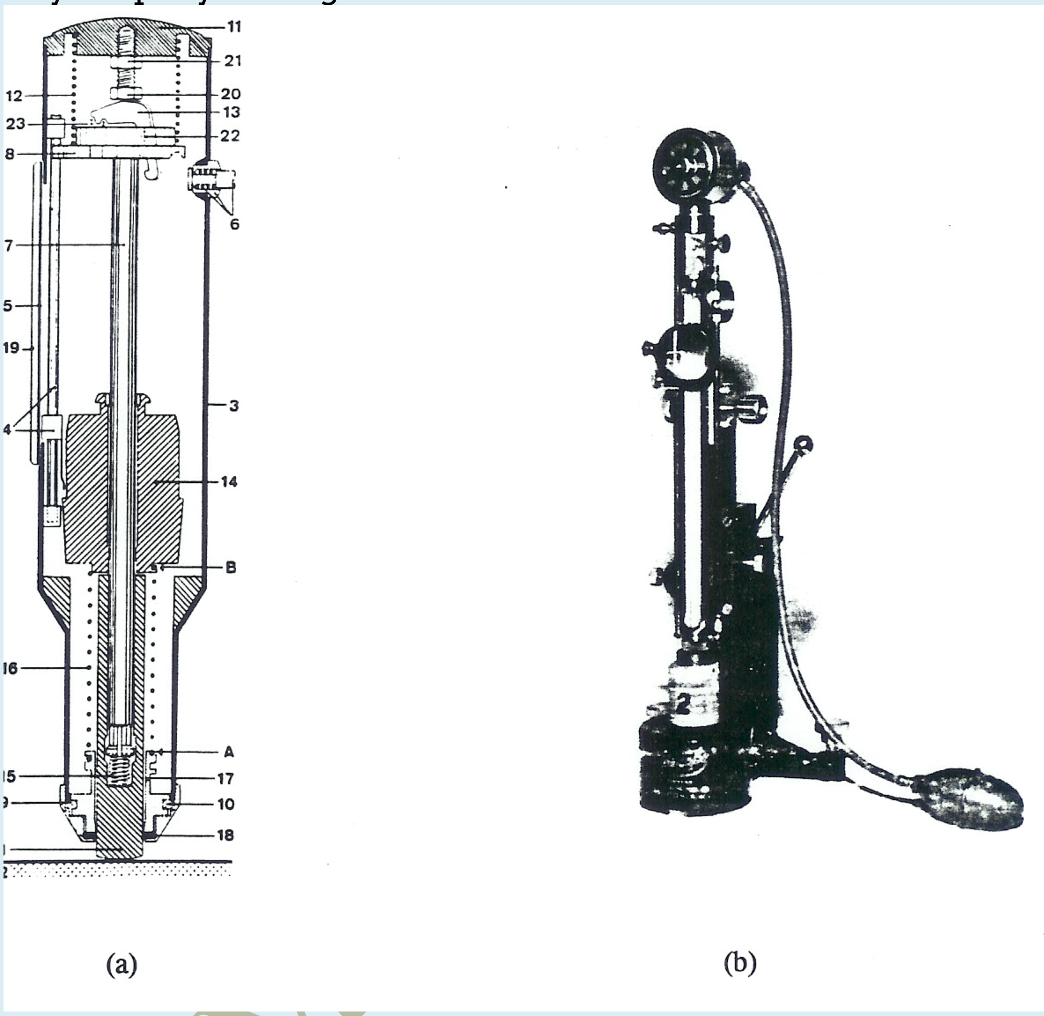

Figure 5 (a) Schmidt Rebound Hammer, (b) Shore Scleroscope. (after Hucka, 1965).

5. DEGREE OF FISSURING

The degree of intact rock fissuring can be characterized through direct observation using the microscope. It can also be characterized through simple tests such as measurement of sonic velocity or permeability.

The sonic velocity method (or pulse method) consists of propagating waves in intact samples of rock. Transmitters and receivers transducers and an oscilloscope are used to measure the time that longitudinal and transverse elastic waves propagate through an intact rock sample .

6 . Porosity

The porosity, n, (expressed in percent) is defined as follows

$$n = \frac{V_v}{V}.100\% \qquad (6)$$

V_v = Volume of voids

V = Total volume of solid

It represents the relative proportion of solid grains and voids in the rock. It is also a measure of the interconnected pore space.

In general, cavities in an intact rock specimen can be classified into two groups: (1) cavities with more or less equal dimensions in all directions called *pores*,and (2) cavities that are elongated called *microfissures.*

6.2 Specific Gravity

The specific gravity of the *solid phase* of a rock, G_s, is defined as follows

$$G_s = \frac{\rho_s}{\rho_w} \qquad (7)$$

where D_s and D_w are the density of the solid particles and water (at 20°C), respectively.

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