Department of Building Engineering

EXERCISE NR 2,3

Stone materials
- determination of bulk density and open porosity
- determination of density and total porosity

Instructions from the lab:
"Building engineering and building materials"

Introduction

The determination of bulk density is performed by one of the following methods:

- direct method on regular samples - when layering, cracking, etc. structural features of the stone material do not prevent obtaining a sample in the shape of a simple geometric body (cube, cylinder, etc.);
- hydrostatic method - when the stone material does not meet the previously set requirements.

The determination of density (specific gravity) is performed, depending on the required accuracy of measurement, by one of the two methods described, namely in a pycnometer or in a Le Chatelier flask.

2.1. Determination of bulk density by hydrostatic method and open porosity (according to PN-EN 1936)

Instruments

To determine bulk density by the hydrostatic method, the following devices are required:

- cabinet dryer with temperature control device;
- vacuum vessel;
- a scale with a weighing accuracy of at least 0.01% of the mass, also allowing the sample to be weighed in water;
- desiccator with drying agent.

Sample preparation and test procedure

From each element, block or fragment of stone intended for testing, at least **six samples** in the form of cubes, cylinders or prisms should be prepared. They should be cut with a diamond saw or cut from a core. The volume of the samples calculated on the basis of geometric measurements should be at least 60 ml. In addition, the surface area to volume ratio should be within the range of 0.08 mm^{-1} to 0.2 mm^{-1}. The samples should be permanently numbered.

Before starting the test, dry each sample to a constant mass at (70 ± 5)°C and cool in a desiccator. Then place the samples in a vacuum vessel and gradually reduce the pressure until (2.0 ± 0.7) kPa = (15 ± 5) mmHg. Maintain this pressure for (2 ± 0.2) h to eliminate the air contained in the open pores of the samples. Slowly introduce demineralized water at a temperature of (20 ± 5)°C into the vessel (the time of complete introduction until the samples are completely immersed should not be less than 15 min). Maintain the pressure of (2.0 ± 0.7) kPa while introducing the water . After this time, restore atmospheric pressure in the vessel and leave the samples under water for the next (24 ± 2) h. Then each sample:

- weigh in water and record the mass in water m_h;
- quickly wipe with a damp cloth and determine the mass m_s of the water-saturated sample.

Calculating the result

Bulk density (g/cm ^{3}) is expressed by the ratio of the mass of a dry sample to its volume, according to the formula:

$$\rho_b = \frac{m_d}{m_s - m_h} \cdot \rho_{rh} \tag{2.1}$$

where: m_d - mass of the sample dried to constant weight, g;

m_s – mass of the sample saturated with water, g;

m_h – sample mass in water, g;

ρ_{rh} – water density at the tested temperature, g/cm ^{3}.

Open porosity

Open porosity is expressed by the ratio (in percent) of the volume of open pores to the volume of the sample, according to the formula:

$$p_o = \frac{m_s - m_d}{m_s - m_h} \cdot 100 \tag{2.2}$$

where: m_d - mass of the sample dried to constant weight, g;

m_s – mass of the sample saturated with water, g;

m_h – sample mass in water, g;

3.1. Determination of density in the Le Chatelier flask

The density test in the Le Chatelier flask provides sufficient measurement accuracy for construction purposes. A general view of the measuring set-up is shown in *Fig. 1. And 2.*

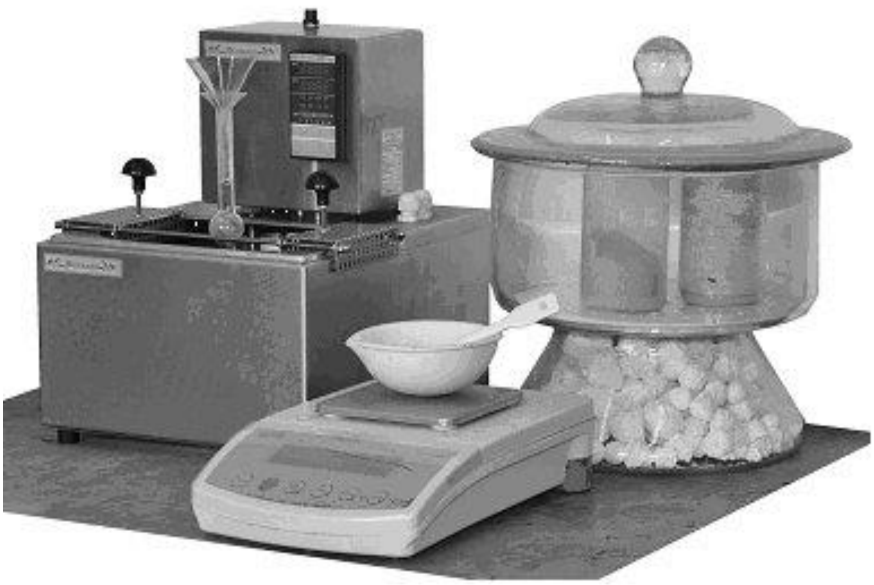

Fig. 1. Devices for determining density by the Le Chatelier method

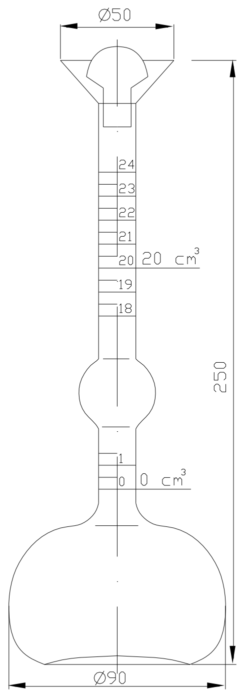

Fig.2. Le Chatelier flask

Instruments

To perform the marking, use the following devices:

- ball mill, agate mortar, hardened steel mortar;
- sieve with square mesh dimensions 0,063 mm;
- cabinet dryer with temperature control device;
- analytical balance;
- Le Chatelier flask (*Fig. 1.2.*), graduated every 0.1 ml;
- desiccator with drying agent;
- thermostat that allows you to maintain a constant temperature of 20± 1°C.

Material samples

The stone material should be crushed in a ball mill or mortar so that all of it passes through a sieve with a mesh side dimension 0,063 mm. If the stone material is contaminated with iron particles, they should be removed with a magnet.

Dry the powdered material to constant mass at a temperature of (70 ± 5) ^{o}C and weigh the mass m_e approx. 50 gto within ± 0,1 g.

Making the marking

Le Chatelier volumeter to the zero mark with deionized water. Then add the weighed powdered sample m_e to the flask in five portions 10 g. Make sure that each portion is immersed in the liquid. After all portions have been added, mix to disperse the powdered sample in the liquid. Read the volume V_s of liquid displaced by the mass m_e of the powdered sample in milliliters to the nearest 0.1 ml from the scale. Before taking the initial level and final volume readings, check that the ambient air temperature is (20 ± 5) ^{o}C.

Test result

The density (specific weight) ρ_r [g/cm^3] of the tested stone material is expressed as the ratio of the mass of the powdered dry sample m_e to the volume of liquid displaced by this mass m_e, in accordance with the formula:

$$\rho_r = \frac{m_e}{V_s} \cdot \rho_{rh} \tag{3.1}$$

where:

m_e - mass of the powdered dry sample, dried to constant weight, g;

V_s - volume of the poured sample corresponding to the volume of liquid displaced by it (reading on the flask), cm^3;

ρ_{rh} - water density at the test temperature, g/cm^3.

The standard requires two determinations. The final result is the arithmetic mean of the density (specific weights) of the stone material calculated for both samples. The permissible difference between the results of the two determinations is 0.02 g/cm^3. If this difference is exceeded, the determination must be repeated.

Total porosity

Open porosity is expressed as the ratio (in percent) of the pore volume (open and closed) to the sample volume, according to the formula:

$$p = \left[1 - \frac{\rho_b}{\rho_r}\right] \cdot 100 \tag{3.2}$$

where:

ρ_b – bulk density of the sample, g/cm ^{3};

ρ_r – sample density, g/cm ^{3}.

LP Group -……/team …… Date………………

1. ………………………………

2. ………………………………

3. ………………………………

4. ………………………………

Exercise 2

DETERMINATION OF BULK DENSITY OF BUILDING MATERIALS BY HYDROSTATIC METHOD

Pattern	Dry sample weight m_d	Mass of sample soaked in air m_s	Mass of sample soaked in water m_h	Volume $V = \frac{m_s - m_h}{\rho_{rh}}$	Bulk density ρ_b
	g	g	g	cm3	g/ cm3
1					
2					
3					
4					
5					
6					
average				average	

Type of tested material: ……………………………..

Test temperature [ºC] t = ……………

Water density at test temperature [g/cm ^{3}] ρ_{rh} = ………….

Open porosity [%] $p_o = \frac{m_s - m_d}{m_s - m_h} \cdot 100 =$ ………% ;

Final remarks:

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LP Group -……/team …… Date……………

1. ………………………………

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Exercise 3

DETERMINATION OF THE DENSITY OF BUILDING MATERIALS IN THE LE CHATE LIERA FLASK AND THEIR POROSITY

Pattern	Sample weight m_e	Volume V_s	Density ρ_r
	g	cm3	g/ cm3
1			
2			
3			
		average:	

Type of tested material: ……………………………..

Test temperature [ºC] t = ……………

Water density at test temperature [g/cm ^{3}] ρ_{rh} = ………….

Total porosity [%] $p = \left[1 - \frac{\rho_b}{\rho_r}\right] \cdot 100 =$ ………%

Final remarks:

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