Faculty of Civil Engineering

WARSAW UNIVERSITY OF TECHNOLOGY

Building Materials

Laboratory exercises

Testing of chosen physical properties of building materials

Author:

Maja Kępniak, PhD

Table of contents

1. The aim of the laboratory

The aim of this exercise is to carry out laboratory tests and calculations of chosen physical properties of building material indicated by the Tutor and to compare the obtained results with the properties of other building materials.

2. Background

2.1. Definitions

Density – mass of a unit of volume of dry material in a powdered state, i.e. of only the material, without pores.

Apparent (volume) density – mass of a unit of volume of dry material together with pores.

Bulk density – mass of a unit of volume of loose materials, in a loose or condensed state.

Tightness – expresses how much of the total volume is taken by the mass of the material, without pores.

Porosity – determining what part of the total volume is taken up by pores.

Water absorption – the total saturation of a given material with water.

Weight absorption – is determined on the basis of the ratio of mass of absorbed water to the mass of the sample in the dry state.

Volume absorption – is defined as the ratio of the mass of water contained in the material to the volume of the material.

Moisture content – the percent of water content of the material at the time of testing.

Water permeability – the susceptibility of the material to the passage of water under pressure over a specified area and test time.

Capillarity – the ability of pulled up a liquid through the capillary tubes (capillaries) of a material in contact with water.

2.2. Introduction

The range of building materials is very diverse and their suitability for a particular application is determined by a number of properties, called technical characteristics. They can be divided into three main groups: physical properties (including mechanical properties), chemical properties and technological properties. Determination of material properties requires laboratory testing. Methods of determining the various characteristics of materials and assessing their quality and suitability are given in specific standards, and measurement techniques are constantly enriched and improved. Physical properties are related to a number of characteristics. Among them, we can distinguish the following: features related to microstructure, external features, fineness, features related to the influence of water and water vapor, features related to the influence of heat and temperature and features related to health effects.

3. Laboratory determinations

3.1. Density measurement in the Le Chatelier flask

3.1.1. Materials and equipment

- Powered sample of the material,
- Alcohol,
- Laboratory scale,
- Laboratory spoon,
- Pipet,
- Le Chatelier'a flask

3.1.2. Measurement

The determination should begin by taking a sample of material weighing approximately 200 g and drying it to a constant mass at a temperature that does not allow changes in chemical or structural composition. Then the sample shall be grinded to a powder of less than 0.5 mm, quartered and sieved through a 0.063 mm sieve.

Fill the test flask with alcohol to 0.00 cm^3 (bottom meniscus). We measure the weight of the calibrated flask. Then we pour in the powdered material gradually. The alcohol level rises. Stop filling the flask when the liquid level rises to the graduation mark corresponding to 20.00 cm^3. Measure the weight of the filled flask. The result is calculated to the nearest 0.001 g/cm^3 from the formula:

$$\rho = \frac{m}{V_a}$$

where:

m – mass of the sample poured in [g],

V_a – absolute volume of sample (without pores) [cm^3].

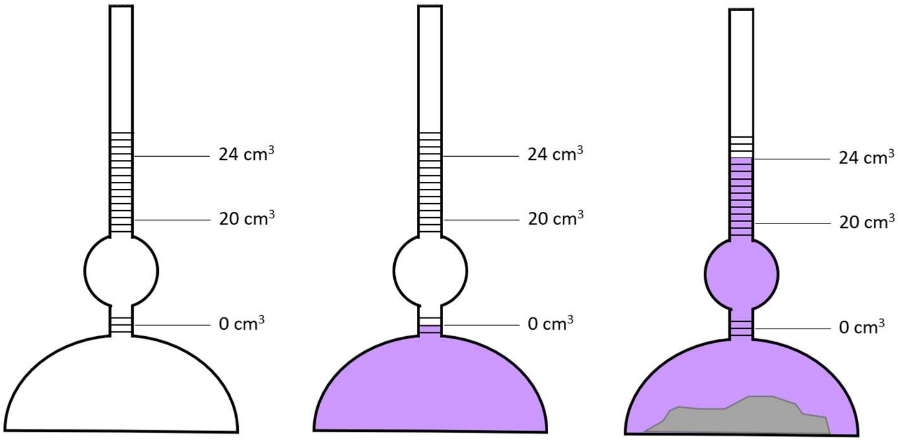

Fig.1. Le Chatelier flask density test procedure

3.2. Apparent density of regular shape specimen

3.2.1. Materials and equipment

- Regular shaped material sample,
- Laboratory scale,
- Calliper or ruler.

3.2.2. Measurement

Size the regular shaped sample and then calculate its volume. The apparent density of the material is calculated to the nearest 0.001 g/cm3 from the formula:

$$\rho_p = \frac{m}{V}$$

where:

m – mass of the sample [g],

V– volume of the sample (with pores) [cm^3].

3.3.Apparent density of irregular shape specimen

3.3.1. Materials and equipment

- Irregular shaped material sample
- Laboratory scale,

- Measuring cylinder.

3.3.2. Measurement

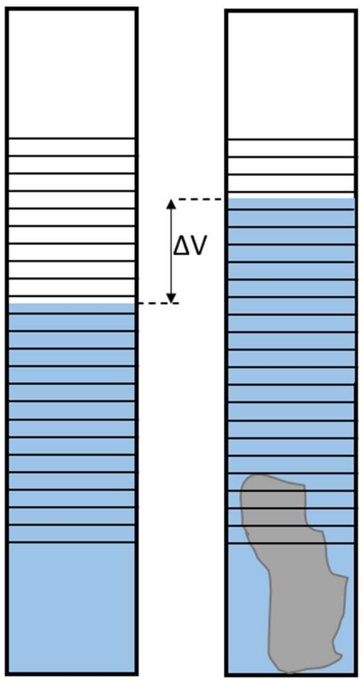

Fig.2. Testing the volume of an irregularly shaped specimen

For an irregularly shaped sample, the volume is determined by the hydrostatic method. The sample is saturated to a constant mass and then weighed in air and water. Another, less accurate, method is to determine the volume of a sample in a measuring cylinder. To make this measurement, fill the cylinder with water to a certain level, e.g., halfway, then place the sample saturated with water in the cylinder and read the difference in liquid levels. The apparent density of the material is calculated with an accuracy of 0.001 g/cm^3 from the formula:

$$\rho_p = \frac{m}{V}$$

where:

m – dry specimen mass [g],

V– volume of the sample (with pores) [cm^3].

3.4.Bulk density

3.4.1. Materials and equipment

- Sample of granular material,
- Laboratory scale,
- Cylindrical container of specified volume (1, 2, 5, 10 dm^3),
- A scraper of adequate length.

3.4.2. Measurement

Determination consists in examining the ratio of the uncompacted mass of dry aggregate filling a specific container to the volume of that container. The dry mass of aggregates filling a specific container shall be determined by weighing and the corresponding bulk density in the loose state shall be calculated. The aggregate shall be dried at (110 ± 5)°C to constant weight. The weight of each sample should be 120% to 150% of the weight needed to fill the container.

Weigh an empty, dry and clean container (mass m_1), place it on a horizontal surface and fill it with aggregate using a scoop until it overflows. When filling the container, minimize grain segregation by resting the bucket on the top edge. In no case should the edge of the bucket be more than 50mm from the edge of the container. Carefully remove any excess aggregate above the top of the container, making sure the surface is even. Level the surface using a scraper, taking care not to crush the surface. Weigh the filled container and record its weight (m_2). Calculate the bulk density in the loose state ρ_{nl} to the nearest 0.001 g/cm^3 from the formula:

$$\rho_{nl} = \frac{m_1 - m_2}{V}$$

where:

m_1 – weigh of the container [g],

m_2 – weigh of the filled container [g],

V– volume of the measuring container [cm^3].

Fig.3. Bulk density test procedure

3.5.Water absorption

3.5.1. Materials and equipment

- Sample of soaked material,
- Laboratory scale,
- Paper towel.

3.5.2. Measurement

A sample of known dry weight is placed in water for 24 hours prior to testing. The specimen is removed from the water and surface dried with a paper towel, and then the mass of the soaked specimen is tested immediately. The mass absorption is calculated to the nearest 0.1% from the formula:

$$n_m = \frac{m_n - m_s}{m_s} \cdot 100\%$$

where:

m_n – mass of the sample in the water saturated state [g],

m_s – mass of the sample dried to constant weight [g].

Absorption by volume is calculated to the nearest 0.001 g/cm^3 from the formula:

$$n_m = \frac{m_n - m_s}{V}$$

where:

m_n – mass of the sample in the water saturated state [g],

m_s – mass of the sample dried to constant weight [g].

V– volume of sample in dry state [cm^3].

3.6.Tightness and porosity

Tightness is the ratio of the apparent density to the density of the material. It indicates how much of the total volume is occupied by the mass of the material under test - without pores. It can also be given as a percentage. It is calculated with the accuracy of 0.001 (0.1%) according to the formula:

$$S = \frac{\rho_p}{\rho}$$

where:

ρ_p – apparent density [g/cm^3],

ρ– density [g/cm^3].

Porosity is a characteristic that determines how much of the total volume is occupied by pores. We calculate it with an accuracy of 0.1% according to the formula:

$$P = (1 - S) \cdot 100\%$$

where:

S- tightness [-].

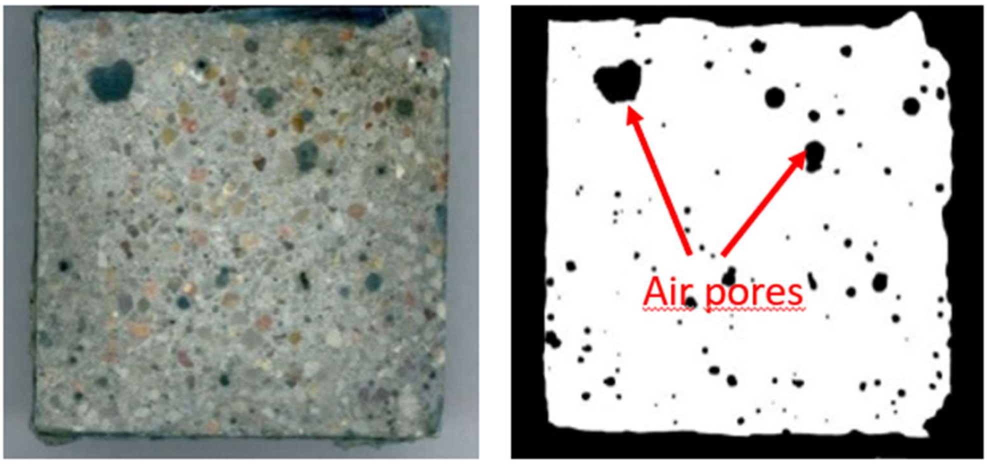

Fig.4. Example of porosity - cement mortar, left side sample encapsulated with resin, right side binary image

4. Summary of the measurements

A summary of the measurements results and the calculations performed should be placed in Table 1, and then the results obtained should be compared with the physical characteristics of other building materials as in Table 2. The figures for the physical characteristics of the building materials selected for comparison are taken from the literature, lecture notes, or the results of other teams in the group.

Tab.1. Results of physical properties of building material

No.	Determination		Unit	Calculations and results	Data of the building material for calculations
1	**Density (ρ) in the Le Chatelier flask**		g/cm^3		
2	**Apparent density (ρ_p)**	**Sample of regular shape**	g/cm^3		
		Sample of irregular shape			
3	**Tightness (S)**		-		Data from determination 1 i 2
			-		Data from determination 1 i 7
4	**Porosity (P)**		%		Data from determination 1 i 2
					Data from determination 1 i 7
5	**Weight water absorption**		%		
6	**Volume water absorption**		g/cm^3		
7	**Apparent density (ρ_p)**		g/cm^3		Data from determination 5 i 6
8	**Bulk density in loose state**		g/cm^3		

Tab.2. Comparision of chosen physical properties of the examined building material with the physical properties of other building materials

No.	Determination	Unit	The examined material …………..	Compared materials		
				…………..	…………..	…………
1	**Density**	g/cm^3				
2	**Apparent density**	g/cm^3				
3	**Tightness**	-				
4	**Porosity**	%				
5	**Water absorption**	%				

5. The report on the laboratory task

The report on the laboratory task should contain:

I. Subject of the study
(basic information about the test material)

II. Test results
(results of measurements and calculations made in the laboratory classes)

III. Conclusions
(statements made on the basis of the obtained results and on the comparison of the obtained results with 3 other building materials)

IV. Literature
(references to the literature used to prepare the report)

6. Literature

- Mamlouk M., Zaniewski J.: Materials for Civil and Construction Engineers
- PN76/B-06714 Mineral aggregate - Crushed stone building aggregate - Technical tests
- PN-EN 1097-7:2008. Tests for mechanical and physical properties of aggregates - Part 7: Determination of the particle density of filler - Pyknometer method