Department of Building Engineering

EXERCISE 4

Building aggregates
- determination of grain composition

Instructions from the lab:

" *Building engineering and building materials* "

4.0 . Determination of grain composition (according to PN-EN 933-1)

This test consists of separating the material, using a set of sieves, into several grain fractions classified according to decreasing dimensions . Both the number of sieves and the dimensions of the holes are selected depending on the type of sample and the required accuracy. The grain composition of mineral aggregates is determined by dry or wet sieving. If washing can change the physical properties of lightweight aggregates, only dry sieving should be used.

The principle of both methods is to separate the aggregate into fractions by sieving (dry, wet) on a set of control sieves with standard square mesh sizes and then determining the percentage (mass) of the individual fractions in the tested sample.

Set of instruments

The following devices are required to determine the grain composition:

- scale or scales with an accuracy of ±0.1% of the analytical sample mass;
- control sieves with holes according to EN 933-2 and compliant with the requirements of ISO 3310-1 and ISO 3310-2;
- shaker for mechanical sieving (optional);
- lower container (bottom) and upper cover adapted to the sieve frames or lower container with the possibility of draining the suspension;
- a dryer with ventilation and a thermostat maintaining the temperature (110 ± 5) ^{o}C or other device for drying aggregates that does not cause changes in the grain dimensions.

The average laboratory sample should be taken in accordance with PN-EN 932-1. The weight and number of samples taken depend on the batch size and type of aggregate to be tested.

The mass of each **analytical sample** of aggregates with a bulk density between 2.00 Mg/m ^{3} and 3.00 Mg/m ^{3} should be as given in Table 1. In the case of other grain dimensions below 63 mm, the minimum mass of the analytical sample may be interpolated from the masses given in Table 1.

The dried analytical sample is cooled to room temperature, weighed and the mass recorded as M_1.

The aggregate analytical sample, tested using the wet method, is then placed in a container and covered with water for 24 h. The solution is stirred at regular intervals to form a suspension by dissolving the clay lumps.

Table 1. Minimum size of aggregate analytical samples

Aggregate grain size D (max) mm	Analytical sample weight (min) kg
90	80
63	40
32	10
16	2.6
8	0.6
≤ 4	0.2

Making the marking

Sieving. The washed and dried material (or directly a dry sample) should be poured onto a set of test sieves placed on the lower container (bottom), successively from the smallest to the largest mesh size. The housings of the individual sieves should ensure tightness of the entire set. If sieving is performed mechanically, the mounted set of sieves should be placed on a shaker.

It is often found that washing does not adequately remove all dust, so a 63 µm sieve should be included in the test sieve set.

Then, the aggregate can be screened. The screening process can be considered complete when the mass of the retained material does not change by more than 1% after 1 min of screening.

To avoid overflowing the sieves, the fraction remaining on each sieve after sieving (expressed in grams) should not exceed the value calculated using the formula:

$$m_i = \frac{A\sqrt{d}}{200} \tag{4.1}$$

where: *And* - area of a given control sieve, mm ^{2};

d - nominal dimension eyes square given sieves control, mm.

If any fraction exceeds the size defined by formula (4.1), the fractions should be divided into smaller portions than the maximum and sieved successively.

After confirming the correctness of the sieving (according to the above formula), the fractions retained on the individual sieves should be weighed using a technical or analytical scale and the individual masses should be recorded as R $_{\text{and}}$. The material remaining on the bottom should also be weighed and this mass marked as P. If aggregate grains have been trapped in the sieve holes, they should be removed by turning the sieve upside down so as not to damage the hole. Such grains are added to the given fraction.

Calculation of results. The particle size distribution should be calculated in percent (m_i/m) to the first decimal place, as follows:

a) calculate the percentage of individual aggregate fractions (a_i) in the analytical sample according to the relationship:

$$a_i = \frac{m_i}{m} \cdot 100 \tag{4.2}$$

where: m_i - total mass of the fraction separated by sieving from the analytical sample, g;

m - mass of analytical sample, g.

b) calculate the percentage of screening through individual sieves (b_n) of the control sieve set according to the relationship:

$$b_n = a_1 + a_2 + \ldots + a_{(n-1)}$$

where: $a_1 + a_2 + \ldots + a_{(n-1)}$ - the sum of percentage shares in the mass of the analytical sample of all aggregate fractions with grains smaller than the mesh size of the control sieve n .

c) calculate the percentage of dust (f) passing through a 63 µm sieve using the formula:

$$f = \frac{(M_1 - M_2) + P}{M_1} \times 100 \tag{4.3}$$

$$f = \frac{P}{M_1} \times 100 \tag{4.4}$$

where: M_1 – mass of dry analytical sample, kg;
M_2 – mass of dry residue on a 63 µm sieve, kg;
P – mass of the sieved material on the bottom, kg.

The result of determining the grain composition should be considered correct if the sum of all fractions ($a_1 + a_2 + \ldots + a_{(n-1)}$) does not differ from the mass of the analytical sample by more than ±1%, i.e. is within the limits of 99 ÷101%. The missing part of the aggregate or its excess should be added/subtracted from the fraction with the highest percentage (the sum of all fractions should be exactly 100%). In the event of a difference greater than 1%, the test should be repeated.

A test report should be prepared for the determination of the grain composition of aggregates. It should contain the following data:

- tabulation of calculated results;
- method of performing the analysis;
- specifying the method of sieving (manual, mechanical);
- dimensions of the test sieve mesh;
- date of marking.

Additionally, it is recommended to graphically present the screening results (so-called aggregate grain size distribution curve or crumb stack curve).

EXAMPLE: *Calculate the grain size composition of the aggregate based on the sieving of a laboratory sample of mass 13 040 gand sketch the graph of the grain size curve. Assume the output data according to Table 2.*

Table 2. Standard sieve sizes and weighed aggregate residues

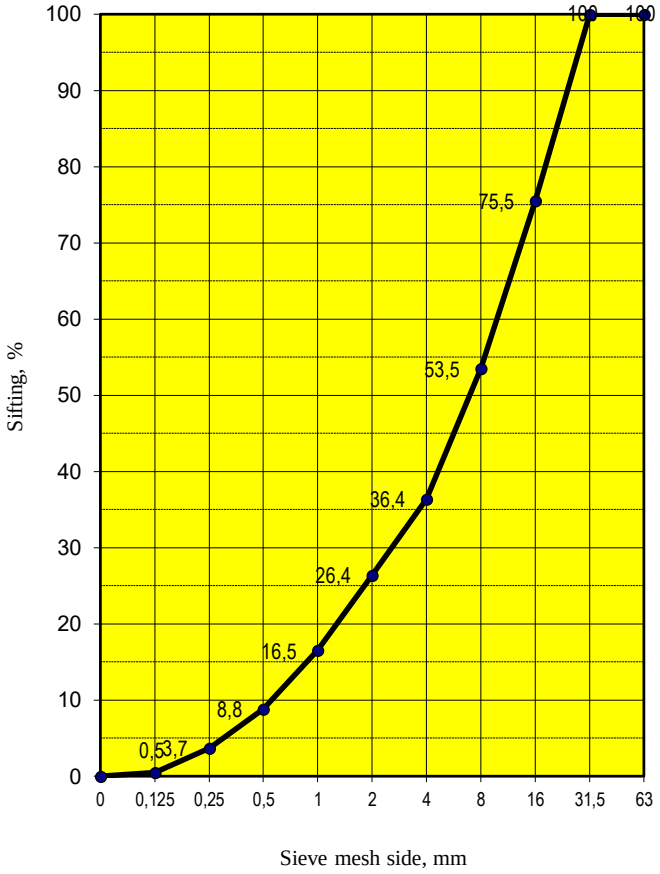
Sieve, mm	63	31.5	16	8	4	2	1	0.5	0.25	0.125	0
Residue, g	*0*	*0*	*3200*	*2870*	*2230*	*1300*	*1290*	*1010*	*660*	*420*	*60*

The calculations were performed in tabular form and are presented in Tab.3, while the results are presented graphically in Fig. 1.

Table 3. Tabulated results of the study

Sieve dimension D mm	Mass of fraction M_{and} g	Share of fraction a_{and} %	Screening b_n %
63	0	0.0	100.0
31.5	0	0.0	100.0
16	3200	24.5	75.5
8	2870	22.0	53.5
4	2230	17.1	36.4
2	1300	10.0	26.4
1	1290	9.9	16.5
0.5	1010	7.7	8.8
0.25	660	5.1	3.7
0.125	420	3.2	0.5
0	60	0.5	0.0
	Total :	100.0	

Fig. 1. Aggregate grain size curve for the discussed example



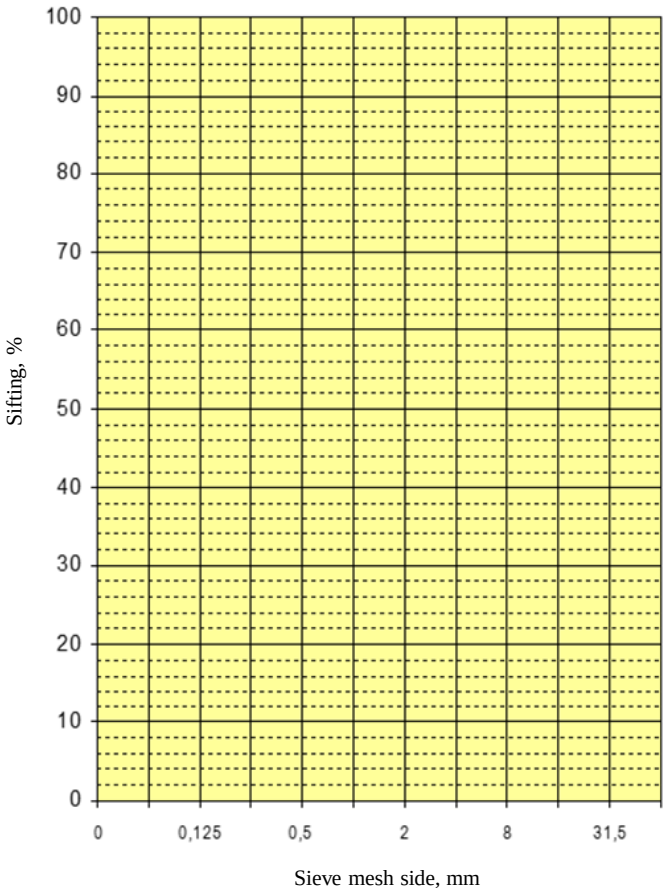
Group ……/team …… Date……

1. ……
2. ……
3. ……
4. ……

Exercise 4

DETERMINATION OF BULK DENSITY AND GRAIN COMPOSITION OF AGGREGATES

Sieving method:			
Total dry mass of the sample before sieving M_{1p} : …… g **Total dry mass of the sample after sieving M_{1k} : …… g** **Lack or surplus of aggregate:** …… %			
Sieve	**Residue on the sieve**		**Sifting**
mm	g	%	%
63.0			
31.5			
16.0			
8.0			
4.0			
2.0			
1.0			
0.5			
0.25			
0.125			
0.063			
0			



Percentage of dust (f) passing through a 63 µm sieve:

$$f = \frac{P}{M_1} \times 100 = \ldots\ldots\ldots\ldots\%$$

Additional comments:

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