AGGREGATES

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Generalities

Aggregates are granular material used in building works. Aggregates can be:

- natural;
- artificial;
- recycled.

Natural aggregates (according to SREN 1262-2003) are any mineral aggregates that have suffered only one mechanical transformation.

Natural aggregates used in concretes can be classified, according to their granule size, in:

- filler: which has the granules less than 0.063m;
- sand: which has the granules less than 4mm;
- rough aggregate: this has the granule equal or bigger than 4mm.

1. AGGREGATE GRADING (for sand 0/4 mm)

The granularity of an aggregate represents the percentage ratios of the sorts which are in the aggregate.

The granularity of an aggregate can be continuous or discontinuous. By sort we mean the aggregate which remains between two consecutive sieves.

Granulometric analyze - Sieving method

According to SR EN 939 – 1/2002, a minimum mass of 0.2 kg of sand has to be used for determination of particle distribution.

The aggregate is washed and dried out first, then it is poured on superior sieve and then manual or mechanic sifting is made.

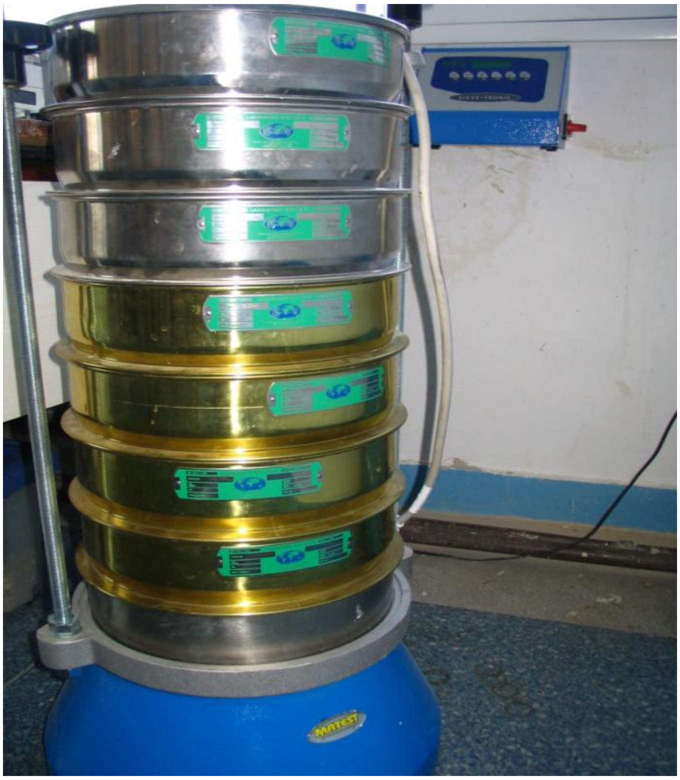

Fig. 1 Mechanical sieves

The following sieves should be used for sand: 0.063; 0.250; 1; 2; 4mm. The sieves are put over a base box in increasing order of the eyes' diameter.

For sand used in mortars, the following passing-through tolerance are accepted by SR EN 13139/2003:

Table 1

Sieve dimension(mm)	Tolerance of mass percentage passing		
	0/4mm	0/2mm	0/1mm
4	±5	-	-
2	-	±5	-
1	±10	±10	±5
0.250	±10	±10	±15
0.063	±2	±3	±.3

The pressing of aggregates' granules on the sieves is forbidden. The granules which remain in sieves' eyes are released by slowly pushing from below upwards. The remaining mass of aggregate on each sieve is weighted. The sum of all quantities should be equal to initial mass **m** of aggregate; the losses must be under 0.5% from **m** and these ones are added to the rest obtained on 0.250 sieve.

The aggregates' granularity will be represented as a curve on a graph with rectangular axes:

- on OX – sieves' diameters;
- on OY – the total percent of passes.

The obtained points are united by straight lines and so the grading curve is obtained. On the same graph, the limits of the tolerances from tables 1 are drawn.

The passing percentages are computed for all sieves by help of the following equation, excepting the sieve 0.063.

$$\%passing = \frac{m - M_{sieve}}{m} * 100 \quad (1)$$

where: m – initial mass of aggregate, in kg;

M_{sieve} – remaining mass of aggregate on the sieve, in kg;

For the sieve 0.063 the equation (2) should be used:

$$\%passing = \frac{(m - M_{0063}) + P}{m} * 100 \quad (2)$$

where:

m – initial mass of aggregate, in kg;

M_{0063} – remaining mass of aggregate on the sieve 0.063, in kg;

P – mass of aggregate that remains on the base box, in kg;

2. VOLUMETRIC MASS OF THE AGGREGATES

For aggregates, bulk volumetric mass should be determined according to SR EN 1097/2003.

Bulk volumetric mass is equal to the ratio between the mass of aggregate and its volume (the volume includes the pores and inter-granule spaces volumes).

$$\rho_g = \frac{m}{V_g} [Kg / m^3] \quad (3)$$

$$V_g = V + V_{pores} + V_{intergranular\ spaces} \quad (4)$$

For the determination of volumetric mass of sand, cylindrical vessels of 1 litre are used.

Uncompacted stage volumetric mass determination for sand

The aggregate is dried out, and then it is poured into determination vessel of known mass (m_1) and volume (V_g) from 10 cm height. After the vessel is filled in excess, the peak of sand is levelled out. The filled vessel is then weighted (m_2). The aerated stage volumetric mass is computed with the following relation:

$$\rho_{ga} = \frac{m_2 - m_1}{V_g} [Kg / m^3] \quad (5)$$

3. INTERGRANULAR POROSITY

The intergranular porosity (V) corresponds to the intergranular goals between particles of aggregate and is computed by use of relation 6:

$$V = \frac{\rho_p - \rho_{ga}}{\rho_p} 100 [Kg / m3] \quad (6)$$

$$1\ell = 1000 \text{ cm}^3 = \frac{1}{1000} \text{cm}^3$$

where: V – intergranular porosity;

ρ_{ga} – bulk volume mass, in kg/m^3;

ρ_p – real volume mass, in kg/m^3.

4. Humidity

For sand, a mass of aggregate of 1 kg is weighted (m_0). The aggregate is dried into a recipient by moderate heat, mixing continuously. The heating is continued until it reaches the following stage: when approaching a glass place to hot surface aggregate, the first one doesn't develop steams on its surface. The aggregate is left to cool out and then weighted again (m_1).

5. IMPURITIES CONTENT

a).The presence of stranger bodies: it can be noticed easily: pieces of clay, micas, granules of sulphates, vegetal or animal rests.

b).The content of humus in sand

For humus content in sand, 200cm³ of undried aggregates are taken into consideration. The aggregates must have $d_{max} \leq 8mm$. The aggregates are introduced into a graduated cylinder of 500 cm³, and a solution of 3% of natrium hydroxide NaOH is poured over them, so that the final volume (aggregate + solution), would be of 300 cm³. We mix well the mixture from the cylinder, for 3 minutes, and then we let it to rest for 24 hours. We observe the colour of solution after 24 hours and compare it with etalon's colour. Maximum admissible colour is yellow.

6. LIGHTWEIGHT PARTS

We will use a 3 dm³ vessel for aggregates like sand ($d_{max} \leq 8mm$) and a 37.5 dm³ vessel for aggregates with $d_{max} > 8\,mm$. Working steps:

- a mass m_0 =0.5 kg is weighted for aggregate with $d_{max} \leq 8mm$ or m_0 =5kg for aggregate with $d_{max} > 8\,mm$;
- the aggregate is introduced in the determination vessel;
- we put water up to 3 cm to the top of the vessel;
- we stir the solution and after this we let it in rest for 15 s;
- we pour the water by inclining the vessel so that the fine particles of aggregate would remain in the vessel;

- we make again the washing of aggregate until the poured water is clean;
- the remaining aggregate is dried out and weighted m_1.

$$\text{\% lightweight parts} = \frac{m_0 - m_1}{m_0} \cdot 100\,\% \qquad (7)$$

where: m_0 - mass of dried aggregate, before washing it, g;

m_1 - mass of washed aggregate, g.

Three consecutive determinations must be made and the final result will be their arithmetical mean.

For aggregates used in hydrotechnics concretes, in zone exposed to freezing — thawing, a maximum of 2% is admitted for sand and 0.5% for gravel.

7. CORRECTION METHODS FOR GRANULOMETRIC COMPOSITION

The correction of the granulometric composition has the purpose to find some optimum mixtures, which have to be between the limits presented in table 2, considering granular sorts or total aggregates which do not have the imposed grading.

a) **Binary graphical method –** is based on knowing the grading of two aggregates A and B and it is used for establishing all possible mixtures between the two aggregates which will be situated between a grading zone limits (table 2).

The method uses a graphical representation (fig.2) which is represented on two vertical axes, at the same scale, the passing through percents of A and B aggregates, and on the horizontal axes the mixing proportion between the two aggregates are represented. In each point of the horizontal axes, %A+%B=100. The passing through percents which correspond to each sieve is marked on vertical axes A and B and is united with a straight line. On each straight line which corresponds to each sieve the utilisation domain limits from table 3.2 are marked (see table 2); the part of the graph from this domain is highlighted.

Table 2 *Correction of gravimetric by Binary graphical method*

Aggregate		**% passing through on sieve:**					
		0.2	**1**	**4**	**8**	**16**	**31**
A		10	45	55	80	90	100
B		-	-	10	25	60	100
Limits	max.	5	20	30	50	70	100
	min.	1	10	20	40	60	95

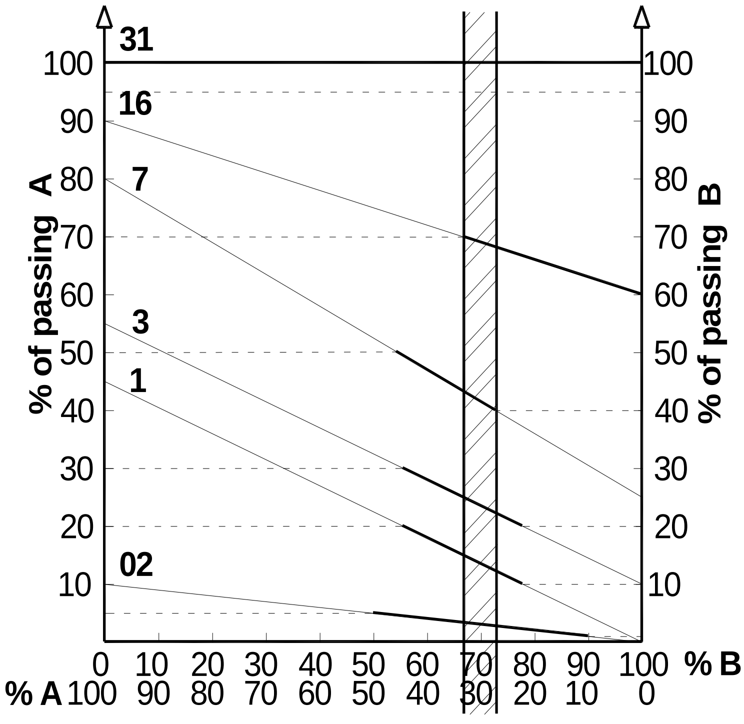

Fig. 2

Optimum compositions are those which are in the imposed grading domain situated between the utilization limits for each sorts (hatched zone in fig. 2).

For aggregates A and B from table 2, the mixtures between the following proportions 33% A+67% B and 27% A+73% B, are in the asked domain for all the sorts.

b) **Graphical method of sum D** is based on knowing the gravimetric composition of two aggregates **A** and **B** and on establishing the mixing combining proportions between them in order to obtain another aggregate **M** which has an imposed grading (table 4). Sum D of an aggregate represents the sum of passing through all the sieves percentages from 02 until the sieve corresponds to the maximum diameter of the aggregate.

Table 3 *Composition correction by Graphical method of sum D*

Aggregate	**% passing through on sieve**						**Sum D**	**Differences**		
	0.2	**1**	**4.0**	**8.0**	**16**	**31**		**D_{AM}**	**D_{MB}**	**D_{AB}**
A	10	45	55	80	90	100	380	116	-	185
B	-	-	10	25	60	100	195	-	69	
M	4	17	27	46	70	100	264	-	-	-

The method uses the graphical representation (fig. 3) in which the values for sum D for the two aggregates and the mixture one M, are put on vertical axes and the mixing proportions on the abscissa. The values of **sum D** for the two aggregates are united and in the place where this straight line intersects the horizontal line, that place represents the **sum D** of aggregate **M**. On vertical axes a straight line is drawn downwards- parallel to vertical axes- and on horizontal axes the mixing proportions between the two given aggregates are determined.

For the given example the mixing proportion is 37% A+63% B.

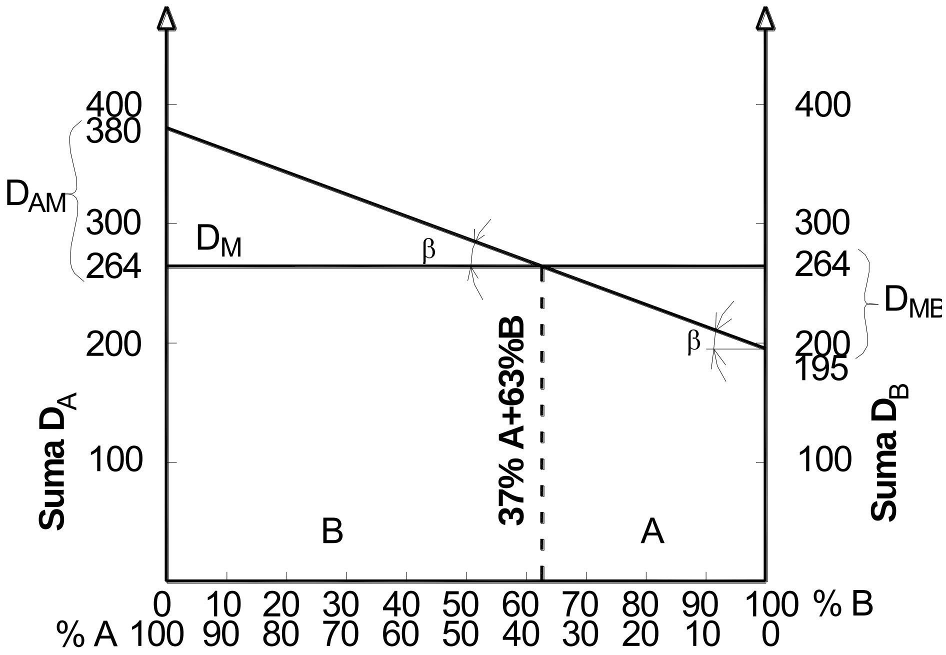

Fig. 3

c) **The method of numerical granularity index (I)** is based on knowing the grading of two aggregates (A and B**)** and the analytical determination of the mixing proportions between them, so that an aggregate M could be obtained having an imposed grading (tab. 3).

The numerical grading index I represent the sum of percents of the rests on the sieves of an aggregate divided by 100.

If the parts of proportion from the final mixture of aggregate A and B, are denoted by x and y then it can be written:

$$\begin{cases} x+y=1 \\ x \cdot I_A + y \cdot I_B = 1 \cdot I_M \end{cases}$$

from where: $x=1-y$

$$y = \frac{I_M - I_A}{I_B - I_A} \qquad (8)$$

For the example, in the table 3, it results that:

$$I_A = \frac{(100-10)+(100-45)+(100-55)+(100-80)+(100-90)+(100-100)}{100} = 2.2$$

and in a similar way:

I_B=4.05 and I_M=3.36 for which results: y=0.63 and x=0.37.

The mixing proportion is 37% A +63% B.

d) **Method of sorts' combination**'s used when we have aggregates which can not be mixed in order to obtain another aggregate which will have its grading limits between utilization limits.

In this case, we shift the aggregates and then the sorts are mixed in order to obtain a proposed grading of an aggregate.

For example: it is asked to combine the elementary sorts so that to obtain an aggregate M which will have the granularity from table 3.

Elementary sorts will be combined such as: sort 0/0.2=4%; sort 0.2/1=17-4=13%; sort 1/4=27-17=10%; sort 4/8=46-27=19%; sort 8/16=70-46=24%; sort 16/31=100-70=30%.

BIBLIOGRAPHY

1. Bob C., Velica Paraschiva, *Materiale de construcții*, Ed. Didactică şi pedagogică, Bucureşti, 1978.

2. Bob C., Velica Paraschiva, Roşu Maria, Meteş Lucia, Roşu Constanța, Jebelean E., *Materiale de construcții*, Îndrumător de laborator, Ed. I. P. „Traian Vuia”, Timişoara, 1978.