CORRELATIONS MECHANICAL STRENGTH - GRANULOMETRIC UNIFORMITY DEGREE FOR PORTLAND CEMENT

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Calitatea cimentului exprimată prin rezistenţele mecanice este influenţată de gradul de uniformitate granulometrică. Din acest motiv, este de interes practic să se evidenţieze corelaţiile care există între rezistenţele mecanice ale cimentului portland şi gradul de uniformitate granulometrică. Pe baza informaţiilor din literatura de specialitate, dar şi a rezultatelor obţinute în urma analizării unor cimenturi româneşti se prezintă o serie de corelaţii între rezistenţele mecanice şi gradul de uniformitate.

Cement quality, expressed as strength, depends on granulometric uniformity degree. For this reason there is a practical interest in corelating mechanical strength of cement and granulometric uniformity degree. Correlations between mechanical strength and granulometric uniformity degree are obtained using literature data and also the analysis romanian marks of Portland cement.

Keywords: granulometric uniformity degree, compressive strength, particle size distribution, diameters, specific surface area.

Introduction

Portland cement has a good capacity of hydration, forming hydrates that can develop hardening structures

The mechanical strenght is the most important mechanical property of the cement because indicates it's behaviour in civil engineering. The literature [1-3] specifies some factors that affect the mechanical strength.

It is well known that in the silicates technology the majority of raw materials consist of polygranular mixtures that can be characterised from granulometric point of view by means of some notions such as: different characteristic diameters (mean diameter, x_{50} diameter, x_{80} diameter etc) [4, 5] specific surface area [5], but also particle size distribution [6, 7].

But, powder mixtures can also be characterized by different granulometric uniformity degrees, UD, even if they have the same mean diameter or specific

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surface area. The uniformity degree, UD, can be calculated or determined experimentally [8-11].

Some authors [1-3, 12-14] reported the influence of grinding fineness on the properties of portland cement, while others [15, 16] showed the influence of the uniformity degree for the powder mixtures.

Beside a series of indices given by the information statistics [5, 8, 9], the uniformity degree, UD for a continuous particle size distribution has been defined as follows:

$$UD=\int_0^{\infty} f^2(x)dx \qquad (1)$$

where f(x) is the continuous dispersion density characterizing the powder particle size dispersion [15].

This work presents correlations between mechanical strengths of Portlend cement and their uniformity degree for various types of Romanian and foreing cements.

Experimental and results

In order to corelate the mechanical strength after different hardening periods of time and uniformity degree we followed two steps:

In the first step the previous data available from the [1, 17, 18] literature were used. The uniformity degree has been calculated (rel. 1) and Fig. 1 reports the correlations between compressive strength of Portlend cement and their uniformity degree. The coefficients for the ecuation used to fit are given in Table 1.

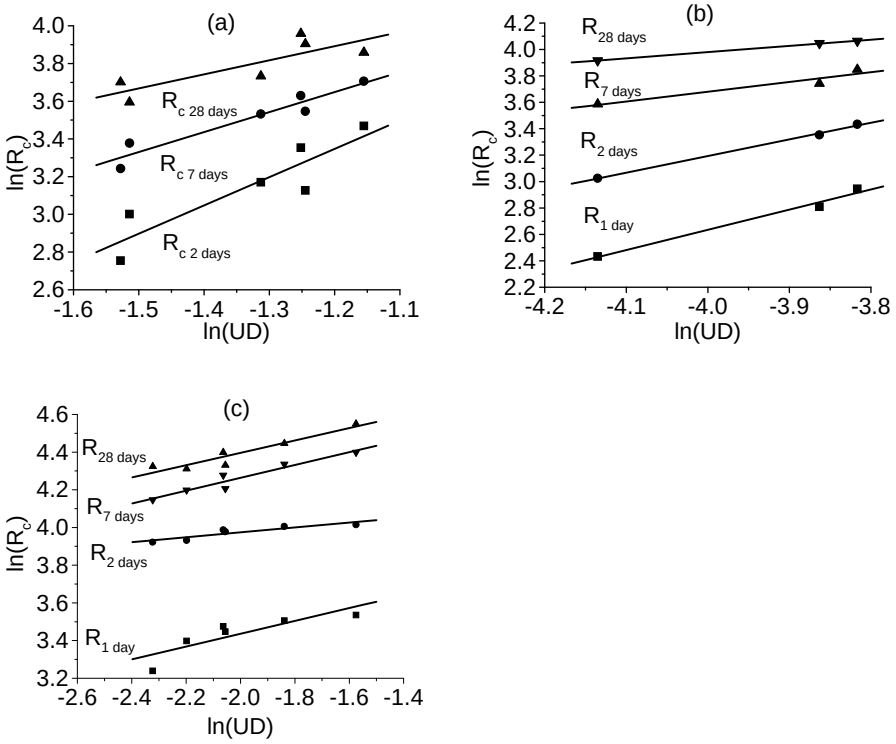

Fig 1 – Variation of the compressive strength with the uniformity degree
[$\ln(R_c) = c + d \ln(UD)$] (a - [1]), (b - [17]), (c - [18])

Table 1.

Values of regression coefficients c, d and correlation coefficient, R, for cements from [1; 17; 18]

No.	Hardening periods	c	d	R	Literature
1	2 day	5.147	1.500	0.903	[1]
	7 days	4.922	1.061	0.958	
	28 days	4.788	0.747	0.827	
2	1 day	8.744	1.527	0.992	[17]
	2 days	8.220	1.256	0.998	
	7 days	6.625	0.736	0.961	
	28 days	5.858	0.469	0.999	
3	1 day	4.116	0.340	0.853	[18]
	3 days	4.234	0.130	0.908	
	7 days	4.946	0.341	0.945	
	28 days	5.051	0.327	0.945	

Using the previous results we propose the following correlation between mechanical strength of cement and their uniformity degree:

$$R_c = a \cdot UD^b \quad N/mm^2 \tag{2}$$

where: R_c - compressive strength, N/mm^2; UD - uniformity degree; a,b - coefficients obtained statistically from experimental data.

Table 2 presents values of regression coefficients a, b and correlation coefficient, R, using literature data from [1, 17, 18]. This change in the magnitude order of the a cefficient is attributed to the differences between cements, from the composition point of view.

The high values of correlation coefficient, R, shows a strong dependence between strength at various ageing times and granulometric unifromity degree. Thus desidered strength can be obtained if an cement has the appropiate uniformity degree.

Table 2.

Values of regression coefficients a and b and correlation coefficient, R, using literature data [1, 17, 18]

No.	Hardening periods	a	b	R	Literature
1	2 day	136.56	1.28	0.973	[1]
	7 days	115.04	0.90	0.994	
	28 days	110.20	0.73	0.999	
2	1 day	6275.50	1.52	0.992	[17]
	2 days	3717.66	1.25	0.998	
	7 days	754.07	0.73	0.961	
	28 days	350.31	0.46	0.999	
3	1 day	61.35	0.34	0.853	[18]
	3 days	69.01	0.13	0.908	
	7 days	140.62	0.34	0.964	
	28 days	156.21	0.32	0.945	

In the second step we used some experimental data for autochthon Portland cements from different cement plants. The particle size distribution and compressive strength after 1, 2 and 28 days were determined. The coefficients a and b were determined using ecuation 2. These coefficients are reported in Table 3.

In this case the magnitude order for a and b are constant and the values for a and b for autochthon cements (Table 3) are lower than those obtained using literature data (Table 1). We explain this defference by the composition and granulometric differences between two kinds of cements.

Also in this case there is a good agreement between the mechanical strength (initial and final) and granulometric uniformity degree (correlation coefficient, R, above 0.90).

Table 3.

Values of regression coefficients a and b and correlation coefficient, R for autochthon cements

No.	Hardening periods	a	b	R
1	1 day	0.17	- 3.36	- 0.993
	2 days	0.57	- 2.78	- 0.994
	7 days	1.95	- 2.19	- 0.994
	28 days	2.10	- 2.28	- 0.993
2	1 day	0.21	- 2.25	- 0.986
	2 days	0.49	- 1.80	- 0.935
	28 days	0.92	- 1.16	- 0.988

Table 4.

Experimental and calculate values for the compressive strength and relative errors for autochthon cements

No.	Cement	1	2	3	4	5	6
	Strength, N/mm^2						
1	experimental						
	1 day	12.3	9.0	14.9	3.6	3.02	4.2
	2 days	18.5	15.3	23.8	4.6	4.1	5.4
	7 days	30.3	26.1	37.0	-	-	-
	28 days	38.1	30.8	43.4	7.9	6.4	8.1
2	calculated with ecuation 2						
	1 day	12.7	8.9	14.5	3.7	2.9	4.1
	2 days	20.0	14.6	22.4	4.8	4.0	5.2
	7 days	32.3	25.6	35.3	-	-	-
	28 days	38.9	30.6	42.7	7.7	6.4	8.2
3	relative errors (%)						
		- 3.3	0.9	2.3	- 3.1	0.8	2.2
		- 8.4	3.9	5.7	- 5.8	1.5	4.0
		- 6.6	1.7	4.5	-	-	-
		- 2.2	0.6	1.5	2.1	- 0.5	- 1.5

Table 4 presents the relative errors for the compressive strength of the autochthon cements after various hardening time. The low values of these errors demonstrate the good correlation between the stregth and the uniformity degree. These correlations are in agreement with the literature data [1, 17, 18].

Conclusions

In cement industry is very important to know the uniformity degree, especially for powders having a uncommon distribution. The uniformity degree is also important because of its influence on the dimensional characteristics of practical interest for the properties of cement (different diameters, specific surface area).

At the same time on the flow sheet of Portland cement the efficiency of powder mixture processing operation depends on the uniformity degree.

By analysing the data from literature but also for autochthon cements a good correlation has been found between the mechanical strength and the uniformity degree. Thus, the uniformity degree has influence on the cement quality expressed as mechanical strength (initial and final).

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