DEVELOPMENT OF NEW CEMENT TYPE CEM II/C-M ACCORDING TO EN 197-5

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ABSTRACT
According to new EN 197-5 is possible to combine clinker with blast furnace slag, silica fume, pozzolana, fly ash, burnt shale, and limestone from 36 – 50% while clinker content should be from 50 – 64%. In this paper are presented results of laboratory testing concerning CEM II/C-M (S+W) production where a sample is prepared by mixing 50% of clinker, 23% of calcareous fly ash, 23% of granulated blast furnace slag, and 4 % of gypsum. The focus was on the physical and mechanical properties of laboratory-produced samples in terms of the specific surface, specific weight, setting time, and tensile/compressive strength. Besides the physical-mechanical properties, the main chemical parameters are also determined (SiO_2, Al_2O_3, Fe_2O_3, CaO, MgO, SO_3, Na_2O, and K_2O). The obtained results of CEM II/C-M (S+W) are compared with the results of cement CEM II/B-W 42,5N.

1. INTRODUCTION

For a long time, one of the main targets in the cement industry is to find a way how to use different types of secondary/alternative materials in this industry. On the global market, there are a lot of materials that can be used in the cement industry in different portions [1]. The new EN 197-5 European standard was created due to the growing need to replace the clinker content with some other alternative materials. Although EN 197-1 European standard cover a wide range of the various main constituents still there is a need for combining these constituents. EN 197-1 is published by the National Standardization Bodies as a national standard in all European countries (e.g. BS EN 197-1)[2].

Even though standard EN 197-1 allows to use of different types of main constituents in cement still there is a need to increase the content of materials that can replace the clinker content in cement [3]. In the past years, a lot of research has been done in order to combine different main constituents in different portions of the final product. All this research is united in the new standard EN 197-5 which is adopted last year. Certainly, the utilization of these materials in cement must be correlated with cement quality [4]. One of the main changes in EN 197-5 is related to limestone properties (L, LL). The calcium carbonate ($CaCO_3$) content calculated from the calcium oxide content shall be at least 40 % by mass and the sum of calcium carbonate and magnesium carbonate ($CaCO_3$ and $MgCO_3$) content calculated from the calcium oxide and magnesium oxide content respectively shall be at least 75 % by mass.The composition of Portland-composite

cement CEM II/C-M and Composite cement CEM VI covered by this document is specified in Table 1 [5].

Table 1. Portland-composite cement CEM II/C-M and Composite cement CEM VI [5]

Main types	Notation of the products (types of cement)		Composition (percentage by mass a)										
			Main constituents										Minor additional constituents
			Clinker	Blast-furnace slag	Silica fume	Pozzolana		Fly ash		Burnt shale	Limestone		
						natural	natural calcined	siliceous	calcareous				
	Type name	Type notation	K	S	D [b]	P	Q	V	W	T	L [c]	LL [c]	
CEM II	Portland-composite cement [d]	CEM II/C-M	50-64	←---------- 36-50 ----------→									0-5
CEM VI	Composite cement	CEM VI (S-P)	35-49	31-59	-	6-20	-	-	-	-	-	-	0-5
		CEM VI (S-V)	35-49	31-59	-	-	-	6-20	-	-	-	-	0-5
		CEM VI (S-L)	35-49	31-59	-	-	-	-	-	-	6-20	-	0-5
		CEM VI (S-LL)	35-49	31-59	-	-	-	-	-	-	-	6-20	0-5

[a] The values in the table refer to the sum of the main and minor additional constituents.

[b] In case of the use of silica fume, the proportion of silica fume is limited to 6-10 % by mass.

[c] In case of the use of limestone, the proportion of limestone (sum of L, LL) is limited to 6-20 % by mass.

[d] The number of main constituents other than clinker is limited to two and these main constituents shall be declared by designation of the cement (for examples, see Clause 6).

In additon, cements covered by this standard shall conform to the requirements listed in the Table 2.

Table 2. Additional requirements and limit values for single results for Portland composite cements CEM II/C-M and composite cements CEM VI [5]

1	2	3	4	5
Property	Test reference	Strength class	Requirements given as characteristic values [a]	Limit values for single results [a]
Sulfate content (as SO_3)	EN 196-2	all	≤ 4,0 [b]	≤ 4,5
Chloride content	EN 196-2	all	≤ 0,10 [c]	≤ 0,10 [c]

[a] Requirements are given as percentage by mass of the final cement.

[b] Portland composite cement with a T content > 20 % may contain up to 4,5 % sulfate (as SO_3) for all strength classes.

[c] Composite cement CEM VI may contain more than 0,10 % chloride by mass. If so, the value of 0,10 % chloride by mass shall be replaced by the upper limit for the chloride content expressed as a percentage by mass with two decimal places and this upper limit shall be stated on the packaging and/or the delivery note.

2. EXPERIMENTAL TECHNIQUES

For this research,a cement sample with a different portion of clinker as a main component, fly ash, granulated blast furnace slag and gypsum as a necessary component in cement is prepared. The recipe for cement sample preparation was:

- Clinker–50 wt. %
- Fly ash – 23 wt. %
- Granulated blast furnace slag –wt. 23 %
- Gypsum – wt. 4 %

Mixing of materials was carried out in the ball laboratory mill, where one of the targets was to reach ~ 4000 cm^2/g Blain-specific surface. After getting the suitable laboratory sampleof cement, the main chemical parameters as SiO_2, Al_2O_3, Fe_2O_3, CaO, MgO, SO_3, Na_2O, and K_2O were determined by the XRF technique.

Concerning physical and mechanical parameters the main parameters as specific surface, specific weight, setting time, and tensile/compressive strength was determined according to EN 197-1 as well.As a reference sample, was taken the cement type CEM II/B-W 42,5N in order to compare results with CEM II/C-M (S+W).

3. RESULTS AND DISCUSSION

The experimental results are presented in Tables 3 and 4.

Table 3. Chemical composition of prepared cement samples

	SiO_2	Al_2O_3	Fe_2O_3	CaO	MgO	SO_3	Na_2O	K_2O
	%	%	%	%	%	%	%	%
CEM II/C-M (S+W)	29,93	8,99	3,88	47,31	2,61	3,26	0,21	0,97
CEM II/B-W 42,5N	27,74	9,77	4,79	50,46	1,56	2,74	0,18	0,84

From Table 3it can be seen that the content of SiO_2 in CEM II/C-M (S+W) is higher than in the case of CEM II/B-W 42,5N. The reason for this is a high portion of granulated blast furnace slag in cement which presents high content of SiO_2.Also, we can notice that CaO content in CEM II/B-W 42,5N is higher than in CEM II/C-M (S+W) and MgO is higher in CEM II/C-M (S+W). The possible problem with CEM II/C-M (S+W) production could be SO_3 content since according to EN 197-1 requirement for $SO_3$is $\leq$ 3,5 % or 4,0 % depending onthe strength class.

Table 4. Physical and mechanical properties of prepared cement samples

	Specific weight (g/cm^3)	Specific surface (cm^2/g)	Stand.conc. (%)	Setting time		Strength (MPa, days)			
						Tensile		Compressive	
				Initial (min)	Final (min)	2	28	2	28
CEM II/C-M (S+W)	2,91	3960	25,4	195	255	2,7	7,4	13,1	42,8
CEM II/B-W 42,5N	2,99	3496	26,7	200	257	3,1	7,8	17,4	51,9

Concerning physical and mechanical properties from Table 4 it is evident that compressive strength after 2 and 28 days is much lower in the case of CEM II/C-M (S+W) than in the case of CEM II/B-W 42,5N. Even though CEM II/B-W 42,5N has a smaller specific surface (Blain) still the compressive strength is significantly higher than in CEM II/C-M (S+W). The reason for this behavior is the lower content of clinker in CEM II/C-M (S+W) since the clinker is still the most important component of strength

development. Other parameters like specific weights, and initial and final times of setting for both types of cementhave similar values.

4. CONCLUSION

- According to the results,it can be concluded that it is possible to produce a new type of cement CEM II/C-M (S+W) which could meet EN 197-5 requirements. In order to get acceptable results, especially in terms of strength, this cement has to be ground for a longerperiod of time than CEM II/B-W 42,5N, to get a higher specific surface. A higher specific surface requires longer grinding time and higher production costs.
- From the experimental results, it is obvious that the specific surface has to be higher than 4000 cm^2/g in order to produce cement CEM II/C-M (S+W) whose 28 days compressive strength will fulfill EN standard requirements.
- Laboratory results show that 28 days compressive strength is on the lower limit and definitely must be higher than 42,8 MPa, as the min. strength is 42,5 MPaaccording to relevant EN standards.

5. REFERENCE

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