

Desulphogypsum from heavy fuel oil (HFO) fired power plant and its use in the cement industry as set retarder

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ABSTRACT: In this study, desulphogypsum of the desulphurization unit of Manisa/Turkey co-generation plant which burns no: 6 heavy fuel oil is tested for its set retarder behavior in cement production. The Investigations have revealed that the desulphogypsum from a HFO fired power plant can be used alone or mixed with natural gypsum as set retarder agent.

1 INTRODUCTION

Set retarders prevent early setting caused by C3A. Gypsum slows down the initial setting time, and accelerates the final setting. Gypsum added to portland cement doesn't only regulate setting time, also regulates properties such as heat change, resistance, shrinkage and cement hydration [1]. It is well known that phospho-, citro-, boro- and especially coal fired power plant desulphogypsum can be used as set retarder agent in cement production and can substitute the natural gypsum [2 -12]. In Turkey, besides coal fired large capacity power plants, HFO powered medium size power plants are also in operation. One of this plants which use high sulphur bearing no: 6 HFO (bunker C HFO) is located in Manisa/Turkey. Wet-limestone process is used for desulphurization of waste gases in this 54 MW co-generation power plant. Presently, desulphogypsum of this plant is dumped as a waste material in amounts reaching up to 75 t/day.

In this study, the utilization of the desulphogypsum of this plant in the cement industry as set retarder was investigated and compared to natural gypsum. All experiments were performed in Cimentas A.S. cement plant (Izmir,Turkey) , quality control laboratories according ASTM and TS (Turkish standards) standards [13].

2. Experimental

2.1. Materials

Desulphogypsum sample was obtained from desulphurisation unit of Manisa power plant. Clinker and natural gypsum samples were taken, from Cimentas A. S. cement plant production line. The chemical compositions of the materials used in the experiments are given in Table 1.

Table 1. Chemical analysis of clinker, desulphogypsum and natural Gypsum

	Clinker	Desulphogypsum	Natural gypsum
SiO ₂	20.51	3.50	2.40
Al ₂ O ₃	5.52	2.89	4.57
Fe ₂ O ₃	3.62	0.20	0.20
CaO	65,54	27.69	28.32
MgO	0.82	0.50	2.54
SO ₃	0.75	42.56	40.47
Loss On Ignition	0.51	22.36	21.50

2.2. Preparation and testing of the cement samples

Different amounts of desulphogypsum, natural gypsum and clinker were interground in a 400 x 400 mm laboratory size ball mill in 2.5 kg charges and for a predetermined grinding time of 21 minutes to the required fineness.

7 different type of cement were prepared. The composition and fineness of them can be seen in Table 2. Blaine values of the ground test cements were close to 2700 cm²/g. In Table 3, chemical properties of test cements determined by X-Ray analyses are given. Vicat water, initial and final setting times and volume constancy test results are given in Table 4.

Table 2. Composition of test cements and their fineness

Cement type	Clinker wt. %	Desulpho gypsum wt. %	Natural gypsum wt. %	+ 90 microns %	+ 32 microns %	Specific surface area (BLAINE) cm ² /g
DSG4	96	4	0	4.3	31.8	2660
DSG5	95	5	0	3.9	33.5	2750
DSG6	94	6	0	4.2	33.6	2770
DSNG5	95	2.5	2.5	3.7	33.5	2720
NG+	96	0	4	3.9	32.3	2730
NG5	95	0	5	3.9	32.7	2690
NG6	94	0	6	4.0	32.0	2730

Table 3. Chemical properties of test cements

	Clinker	DSG4	DSG5	DSG6	DSNG5	NG4	NG5	NG6
Free CaO	1.29	0.93	0.78	0.75	0.84	0.86	0.85	0.87
Aluminate Module	1.53	1.59	1.61	1.61	1.60	1.61	1.60	1.54
Silicate Module	2.25	2.05	2.4	2.04	2.04	2.04	2.04	2.08
Lime standart	98.85	98.48	98.85	98.09	99.32	98.76	99.61	99.33
C ₃ S	63.40	59.06	59.4	57.40	60.28	59.79	60.69	60.77
C ₂ S	10.98	10.83	9.66	10.99	8.89	10.18	8.36	8.69
C ₃ A	8.50	9.14	9.22	9.16	9.10	9.34	9.09	8.61
C ₄ AF	11.01	11.08	10.93	10.84	10.91	11.04	10.85	10.95
SO ₃	0.75	2.30	2.86	3.31	2.59	2.16	2.46	3.04

Table 4. Vicat water, initial setting, final setting times and volume constancy of the test cements

Sample name	Vicat water %	Initial setting time (hour:min)	Final setting time (hour:min)	Volume Constancy (mm)
TS 24	-	1:00 (min.)	10:00 (max.)	10 (max.)
DSG4	26.6	2:45	4:20	1
DSG5	26.2	2:35	4:00	2
DSG6	25.8	2:45	4:15	2
DSNG5	25.6	2:30	3:50	0
NG4	26.6	2:35	3:35	0
NG5	25.8	2:20	3:50	2
NG6	26.0	2:30	3:45	2

Standard sand, according to TS 19 , was used when preparing concrete samples. The concrete samples were cured up according to standards. Samples were undergone compressive strength tests after 2, 7 and 28 days (Table 5).

Table 5. Compressive Strength Values

Sample name	2 Days MPa	7 Days MPa	28 Days MPa
DSG4	22.4	34.4	46.7
DSG5	21.8	35.2	46.8
DSG6	20.7	34.7	49.6
DSNG5	22.2	36.6	47.7
NG4	22.7	36.4	45.3
NG5	22.1	34.9	45.4
NG6	20.9	33.5	45.2

3. Results

Desulphogypsum retards initial and final setting times more than natural gypsum. The longest initial and final setting times were recorded for DSG4 sample which includes 4 % of desulphogypsum.

Vicat water amount and volume constancy values for the cement samples prepared with desulphogypsum are similar to those with samples prepared with natural gypsum.

Desulphogypsum has no adverse effects on concrete strength. According to the results of 28 days compressive strength tests, cements prepared with desulphogypsum show slightly higher 28 days compressive strengths.

Encouraged from the results of this study Cimentas A.S. run some industrial scale tests with desulphogypsum and obtained satisfactory results.

4. Conclusion

From the experimental results presented in this paper it can be concluded that desulphogypsum from a HFO fired power plant can be used as set retarder agent and substitute natural gypsum in cement production. It can be used alone or mixed with natural gypsum.

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