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THE EFFECT OF DRY SLUDGE ADDITION SUPPLIED FROM PULP MILL ON THE COMPRESSIVE STRENGTH OF CEMENT

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ABSTRACT

Alternative ecological and economic waste recovery techniques have been developed and implemented in pulp and paper industry due to the increase in the amount of waste and the pressure from the environmental movements in the last decade. In this study, solid waste obtained from kraft pulp mill's recovery unit known as lime mud was investigated on cement stabilization. Some chemical and physical characteristics of obtained solid waste and composite cement (CC:32.5) were analysed prior to making composite. Then composite cement was treated with lime mud waste with various ratio. Properties of samples were determined according to standards by realizing compressive strength, initial setting time, blain fineness, specific gravity, Le Chateller soundness and water content tests. Compressive strengths results indicated that the gain compressive strength depends on curing time and compressive strength increases as cement content increases. As a result, it can be suggested that lime mud is practically used as additive in composite cement manufacturing to some extent.

Keywords:composite cement, compressive strength, pulp industry solid waste stabilization.

INTRODUCTION

Large quantities of industrial wastes are stabilized with cement or used as an additive material in cement manufacturing sector. Suitable materials are fly ash collected from power plants, municipal solid waste, and some industrial wastes [1].

For the production of cement, alternative fuels and raw materials are increasingly being used to produce clinker. The uncertain environmental properties of the cements, when used in construction materials, during these materials' service life (primary application in intact structures) and any "second life" (construction debris used as aggregate in concrete or unbound in road construction), have been raised as matters for concern in relation to the increasing use of such alternative fuels and raw materials [2].

Cement-based binders are frequently used for the solidification and stabilization processes of hazardous wastes. The negative influence of waste on the hydration reactions of cement-based binders require further study in order to optimize the characteristics of these binders [3].

The clear improvement in the performance characteristics of the resulting cement using fly ash as a component of raw mix, and enables replacement of Shale

Table 1. Physical properties and chemical composition of Lime mud and composite cement.

	Lime Mud (%)	Composite cements (CC:32.5) (%)
Physical Properties		
Blain fineness (cm^2/g)	4664	3457
Water content (%)	28.00	22.30
Loss on ignition (%)	47.00	3.56
Specific Weight (g/cm^3)	2.43	2.90
Fineness (90μ/200μ) (%)	39.8/80.6	0.2/3.9
Le Chateller Soundness (mm)	-	1
Setting time -initial	-	125
(minute) -final	-	295
Compressive strength, N/mm^2		
-2 days	-	15.6
-7 days	-	28.7
-28 days	-	41.3
Chemical composition		
SiO_2	9.19	27.19
Al_2O_3	0.10	5.39
Fe_2O_3	0.07	3.38
MgO	0.15	1.23
CaO	40.09	54.01
Na_2O	3.01	0.82
K_2O	0.19	1.01
SO_3	0.02	2.19
LOI	47.00	3.56
PH	10.50	-

and Iron ore as a raw mix component. Lowering clinkering temperature was an advantage too [4].

Mixtures of MSW fly ash stabilized with cement and fluidized bed combustion coal fly ash FCA were used for unconfined compressive strength tests, leachate tests, and soaking tests [5]. The cement stabilization of the MSW fly ash does not have enough effect on strength development and soaking durability. When using FCA as a stabilizing agent for MSW fly ash, the mixture exhibits high strength and durability.

In another study Gulay [6] investigated chemical and mineralogical analysis of the sludge produced during drinking water treatment. The cement samples were produced for the testing of the compressive strength, curing period, moisture content specific gravity, expansion of volume, etc. No significant change in the density of the cement produced was observed with increasing the amount of the sludge added to Portland cement.

Karinaj and Havanagi [7] conducted an experimental study on cement stabilized fly ash-soil mixtures. The gain in strength and modules was dependent on the fly ash and cement contents. The cement content had a significantly higher influence than the fly ash content. The water content of a fly ash-soil mixture depended on the curing time and cement content. The water content decreased as curing time and cement content increase.

In this study, the capability of using lime mud that disposed by commonly land-filling method obtained from CAY Pulp Mill in Turkey on cement manufacturing sector was investigated. Thus, compressive strength values of samples which evaluated various ratios of lime mud and composite cement mixture were determined.

EXPERIMENTAL

Solid waste or lime mud used in this study was supplied from CAY Pulping Mill-Turkey where 30.000 t/year bleached kraft pulp was produced. As a raw material 65% wheat straw (*Triticum sativum L.*) and 35% common reed (Phragmites australis) were used. Composite cement (CC:32.5) was supplied from State Cement Factory in Trabzon, Turkey. Lime mud which was discharged from mud filter after rinsing of white mate-

Table 2. Properties of TS 819 Rilem Cembureau Standard Sand.

Sieve size (mm)	Fineness Percentage remaining (%)
0.08	98 ± 2
0.16	87 ± 2
0.50	67 ± 2
1.00	33 ± 2
1.60	9 ± 2
2.00	0
Specific Weight	3.03-3.15 (g/cm³)

rial and washing of mud after processing of caustification in recovery unit of CAY craft pulping mill. In generally, this lime mud is abandoned to nature because it has more silicate rate due to the use of reed and straw as a raw material.

The chemical analysis of lime mud was made in ACME laboratory in Canada. The composite cement was prepared in Trabzon cement factory laboratory. The chemical composition of lime mud and the composite cement are shown in Table 1.

To realize the compressive strength test mortar mixture was constituted. This mixture includes composite cement, lime mud and TS 819 [8] Rilem Cembureau standard sand. The properties of TS 819 [8] Rilem Cembureau standart sand are shown in Table 2.

Lime mud was used as additive for composite cement as 5, 10, 15, 20, 25, 30 % replacement amounts (by mass) to produce composite-lime mud cements. The pastes were cured at 20 ± 1°C and insulated so that the curing could be done under their own humidity. The compressive strengths at 1, 2, 7, 28, 35, 45, 60, 75, 85, 90 days, setting time and normal consistencies of the cement were determined according to Turkish Standard TS24 [9].

RESULTS AND DISCUSSION

The samples were prepared as 2 kg for all experimental studies. In this sample, when the rate of additive was determined, for instance 5 % lime mud additive samples include 100 g. lime mud, 1900 g composite cement plus aggregate. After the mixing operation different additive materials were poured with dimension of 4X4X16 cm modules with procedure for mortar.

The results obtained from the compressive strength test are shown in Fig. 1 and Fig.2 according to the lime mud ratio and the time, respectively. While the lime mud ratio increased the compressive strength values decreased. Also, the compressive strength values decreased while the lime mud ratio increased after 7 days, but the values were not very different for the same lime mud ratio. For 1 day, the compressive strength

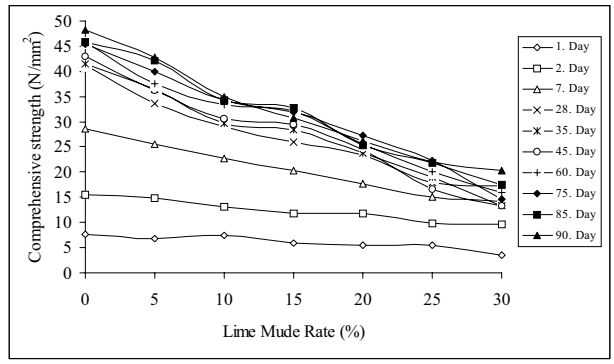

Fig. 1. The compressive strength values of curing time according to lime mud ratio.

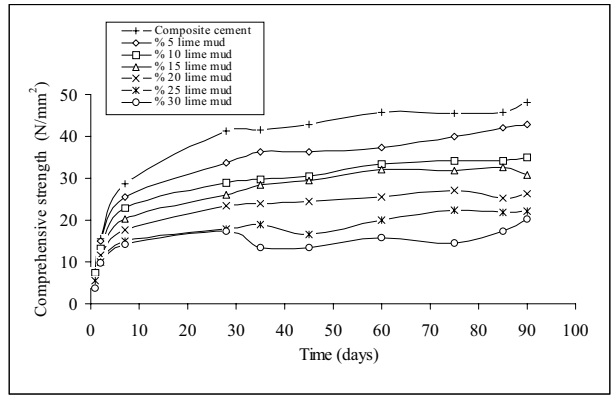

Fig. 2. The compressive strength values of lime mud ratio according to the time.

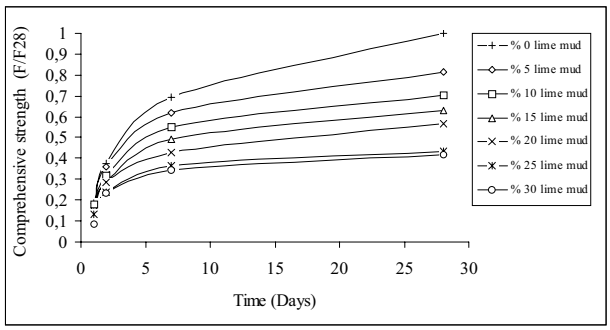

Fig. 3. Compressive strength ratio according to the time (puzzolanic activity).

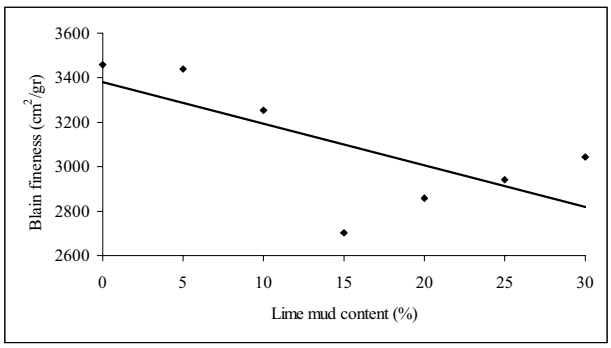

Fig. 4. Variation of blain fineness according to the lime mud content.

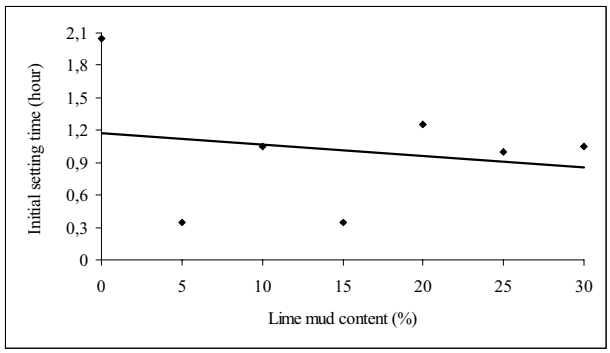

Fig. 5. Variation of the initial setting time according to the lime mud content.

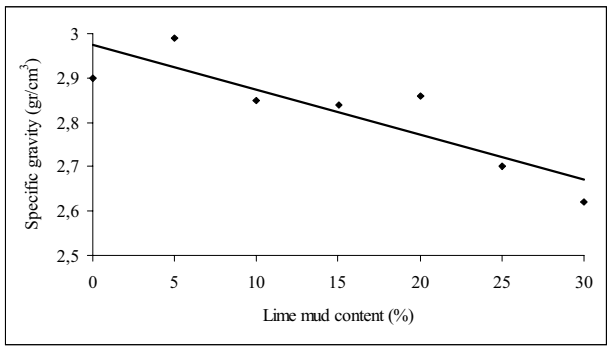

Fig. 6. Variation of the specific mass according to the lime mud content.

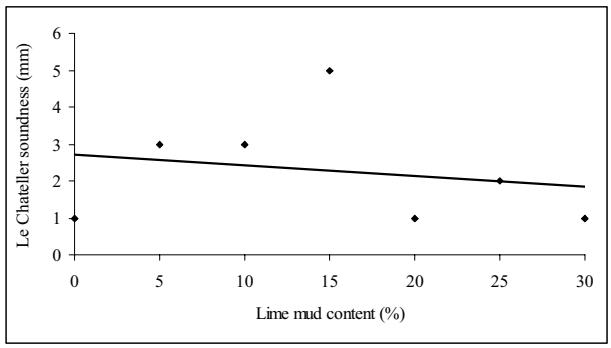

Fig. 7. Variation of Le Chateller soundness according to the lime mud content.

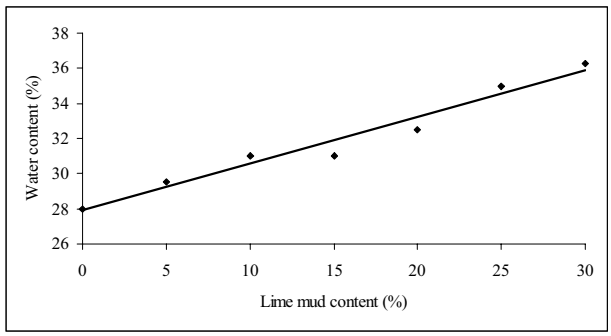

Fig. 8. Variation of water content according to the lime mud content.

values were similar to the values of the composite cement at 5 and 10 % lime mud additive samples. Following days, although, the compressive strength values of the samples were lower than the values of the composite cement, the strength values 5 % lime mud additive samples were similar to the values of the composite cement.

Puzzolanic activity should not be less than 70 % for 28 days according to TS 639 [10]. In this study, puzzolanic activity was 80 % at 28 days for 5 % lime mud content and 70 % for 10 % lime mud content. (Fig. 3).

As shown in Fig. 4, while lime mud content was from 0 to 15 % values of blain fineness decreased. After then, the blain fineness values increased while the lime mud content increased. The decrease of blain fineness indicated that fineness of sample was lower than normal. This caused the decreasing of survey of water contact and also caused slow reaction and long setting time.

When the initial setting time of the samples was investigated, it can not be said that there was a relation

between the lime mud content and the initial setting time. But it can be said that the initial setting time had the lowest value for 5 and 15 % lime mud content and the highest value for 20 % lime mud content and, for the other lime mud content, the initial setting time had medium values (Fig. 5).

In general, the specific gravity values of the samples decreased as the lime mud content increased. Only for 5 % lime mud content, the specific gravity values were higher than those of the composite cement (Fig. 6).

The specific gravity value gave an advice about the mixture possibilities of the cement and some filling materials and the hydratation properties of cement when it can not be conserved in a dry place. Besides, although the specific gravity value does not indicated the cement quality, it was very important because it is used on calculation of the material ratio for the concrete mixtures [11].

An increase in the lime mud content to 15 % caused an increase of Le Chateller soundness value. While the lime mud content increased from 15 % to 30 %, Le Chateller soundness values decreased. Value of Le Chateller soundness was 5 mm for 15 % lime mud content and was similar to the composite cement for 20 % lime mud content (Fig. 7). All Le Chateller soundness values obtained from the experiment agreed with the standard volume soundness value (<10 mm).

Water content of the samples increased while the lime mud content increased (Fig. 8) because the amount of Na_2O and K_2O in the lime mud was more than in the composite cement.

CONCLUSIONS

It can be concluded that the pulp industry solid waste or the lime mud can be used practically as an additive in the composite cement manufacturing. The gain compressive strength was found to be experimentally depended on the curing time. The compressive strength values increased as the curing time increased. The gain in compressive strength increased as the cement content increased, but decreased as lime mud content increased. Puzzolanic activity at 28 days curing time for 5 % lime mud content was found to be 80 % and for 10 % lime mud content was 70 %.

The blain fineness decreased as the lime mud content increased to 15 % and it increased as lime mud content increased from 15 % to 30 %. In general the specific gravity decreased as the lime mud content increased, but the specific gravity increased only at 5 % lime mud content. The Le Chateller soundness increased as lime mud content increased to 15 % and it decreased as the lime mud content increased from 15 % to 30 %. The water content of the composite cement and the lime mud mixtures were found to be depended on the lime mud content. The water content increased as the lime mud content increased.

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