ACTA TECHNICA CORVINIENSIS
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STUDIES REGARDING OF SIDERITIC RESIDUE UTILIZATION FOR CEMENT PRODUCTION

Abstract:
The paper presents the experimentations made in the laboratories of Faculties of Engineering from Hunedoara and also in the frame of Carpatcement Holding Deva laboratories, looking at the introduction of the sideritic residue along with the clinker, for obtain of cement. For suggested recipe, were determinate the specific surfaces, setting time, compression strength. Result obtained in the laboratory condition proven as the proposal is viable as much from economic and ecologic point of view, through the recycling of manufactured residue existing in very big amounts in approach of Hunedoara area.

Keywords:
sideritic residue, clinker production, cement, polluted surface, recycling

INTRODUCTION

The Portland cement is the most used binding material into construction, due to its properties, which are depending upon the chemical and mineralogical composition, manufacturing conditions etc. Portland cement has, normally, the following chemical composition:

$CaO = 60 – 65$ %; $SiO_2 = 18 –24$ %;
$Al_2O_3 = 5 –10$ % ; $Fe_2O_3 = 1 – 4$ %; $MgO < 0$.

From the point of view of the formal constituted elements, the chemical composition is presenting as follows:

- tricalcic silicate ($3CaO·SiO_2$) symbolized C_3S, in ratio of 47%;
- tricalcic silicate ($2CaO·SiO_2$) symbolized C_2S, in ratio of 28%;
- tricalcic aluminates ($3CaOAl_2O_3$) symbolized C_3A, in ratio of 11%;
- ferialuminat tricalcic ($4CaO·Al_2O_3· Fe_2O_3$) symbolized C4AF, in ratio of 8%;
- $CaSO_4$ (3%); MgO (2%); CaO_{liber} (0,5%); Na_2O (0,5%).[2]

The cement is obtained by raw material burning and smelting into the special installation: by dried, semi-dried, semi-wet and wet proceedings.

The raw material that is used for Portland cement manufacturing is composed by:

- calcareous rocs, with an calcite content of 75- 80%;
- clay, with content of SiO_2, Al_2O_3 , Fe_2O_3;
- adjustment adding, like:
    - bauxite, for increasing Al_2O_3 content;
    - diatomite, for increasing SiO_2 content;
    - ferric disulphide ashes, witch bring Fe_2O_3 and decreasing temperature of clinkerization process;

- *metallurgical slag, witch bring Fe_2O_3, thermo-central ashes and*
- *others wastes.*

We are considering with a fundamental base technological solution of recycling the sideritic waste material, resulted on the cement producing.

THE STUDY

Aspects concerning the sideritic residue sludge beds are presented in figure 1.
The sideritic residue granulometric composition is presented in table 1. The simple granulometric curve is presented in figure 2 and the cumulate granulometric curves are presented in figure 3.

Figure 1. a. Aspects concerning the sideritic residue sludge beds: sludge bed 1

Figure 1. b. Aspects concerning the sideritic residue sludge beds: sludge bed 2

Figure 1. c. Aspects concerning the sideritic residue sludge beds: sludge bed 3.

Tab.1. The sideritic residue granulometric composition

Material	Granulometric classes, [μm]						
	< 25	25-56	56-90	90-180	180-315	315-500	> 500
Sideritic residue	2,19	3,30	6,42	32,79	50,72	3,97	0,61

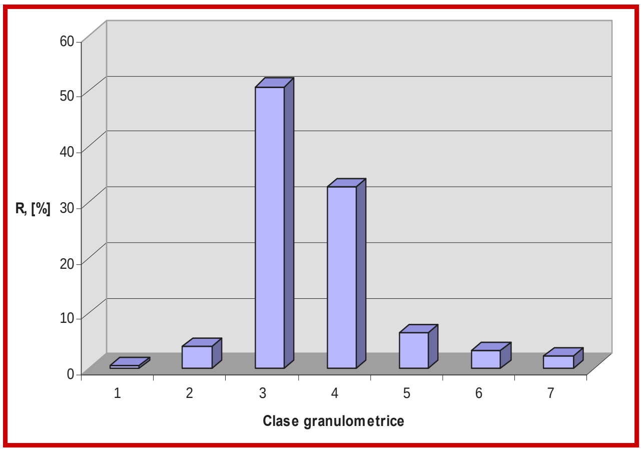

Figure 2. The simple granulometric curve

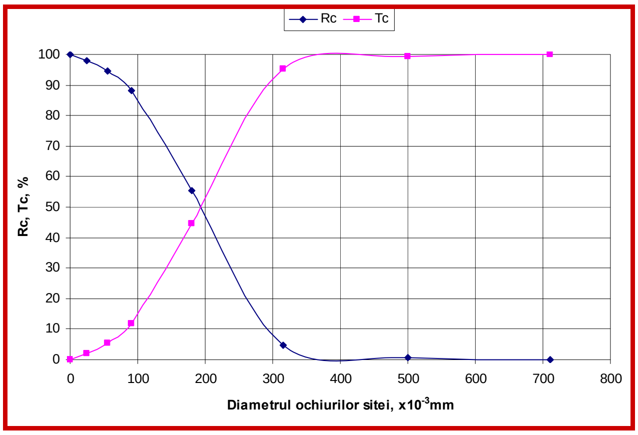

Figure 3. The cumulate granulometric curves

Figure 4.a. The raw materials: clinker

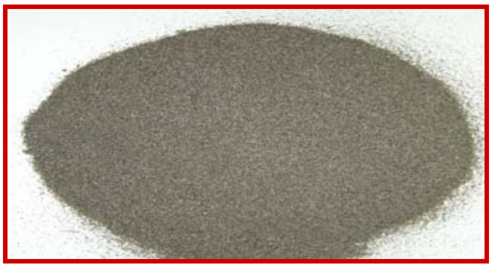

Figure 4.b. The raw materials: sideritic waste

Figure 4.c. The raw materials: calcined gypsum

For experimentations, in order to obtained cement, we elaborated 7 cement recipes, introducing various quantities of clinker and sideritic waste, as well as 5% burnt plaster (fig.4). The details are shown in tab.2 and graphically in fig.5.

Tab.2. The experimented cement recipes components

Component, [%]	Recipe no.						
	1	2	3	4	5	6	7
Clinker	90	85	80	75	70	65	60
Sideritic residue	5	10	15	20	25	30	35
Calcined gypsum	5	5	5	5	5	5	5
Total	100	100	100	100	100	100	100

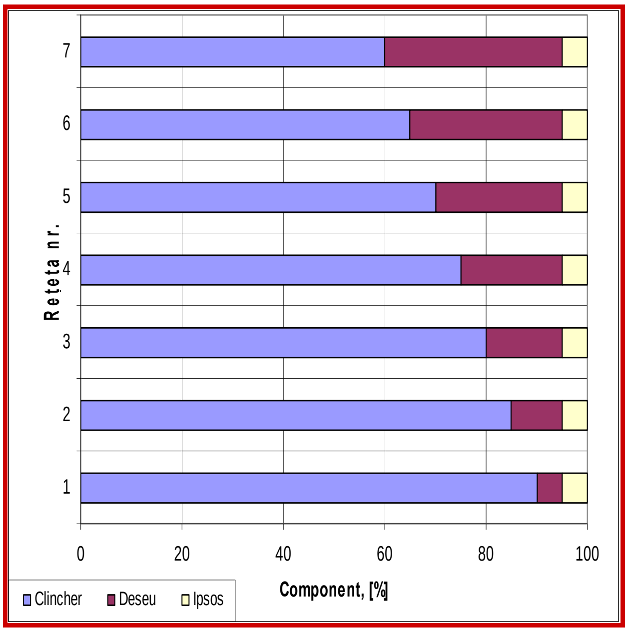

Figure 5. Used recipes

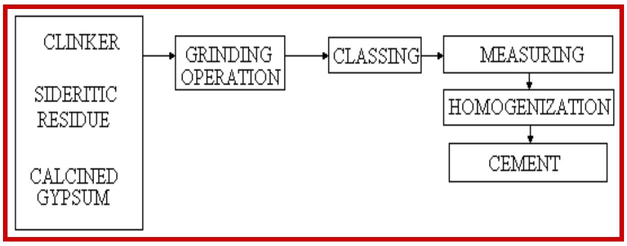

Figure 6. Cement technological flux in laboratory condition

In order to determine the quality of our recipes we elaborated a 1 kg sample for each of them, according to the procedures shown in fig.6. We used in this scope the installations existing in the laboratories of our Faculty [3].

ANALISES, DISCUSIONS, APPROACHES, INTERPRETATIONS

The determination of quality has been done as follows:

- we performed the chemical analysis of the samples, the results being given in tab.3;
- we determined the specific surface of the cement mixture, tab.4;
- we carried out cement specific tests and determinations such as: the determination of water for the normal consistence paste, the binding time, resistance to pressure after 1, 2 and 7 days from binding – tab.5.

The tests have been done both in our laboratories and with the help and participation of our contract partner: CARPATCEMENT HOLDING, Deva branch. The chemical structure varied as shown in tab.3.

Tab.3. Chemical composition for our cement recipes

Recipe no.	Chemical composition, [%]			
	CaO	SiO_2	Al_2O_3	Fe_2O_3
1	60,53	20,78	5,00	3,64
2	58,04	21,44	4,88	3,85
3	55,54	22,10	4,75	4,06
4	53,04	22,76	4,62	4,28
5	50,54	23,42	4,50	4,49
6	48,04	24,08	4,37	4,70
7	45,55	24,74	4,24	4,91

Recipe no.	Chemical composition, [%]		
	Others oxides	P.C.	$CaSO_4*0,5H_2O$
1	3,97	1,17	4,90
2	4,54	2,35	4,90
3	5,12	3,52	4,90
4	5,70	4,69	4,90
5	6,28	5,87	4,90
6	6,86	7,04	4,90
7	7,44	8,21	4,90

In order to determine the specific surface, we used the Blaine permeability meter shown in fig.7 – from the laboratories of CARPATCEMENT HOLDING, Deva branch. The data we obtained are given in tab.4 and in figure 8.

Figure 7. The Blaine Permeability-meter

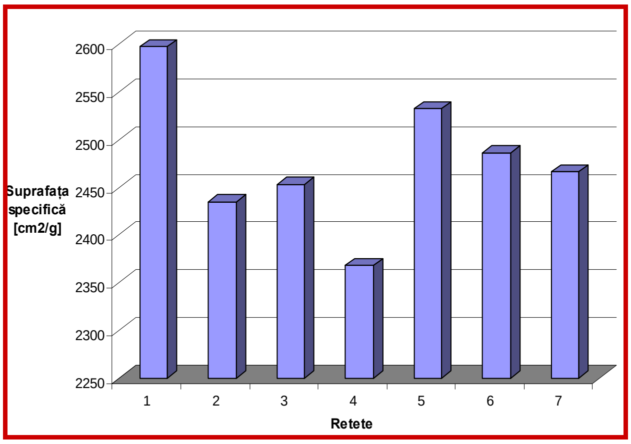

Figure 8 Specific surface for our cement recipe

Tab.4. Resulting data for specific surface

Specific surface [cm^2/g]	Recipe no.						
	1	2	3	4	5	6	7
	2597	2435	2453	2368	2532	2486	2466

Figure 9. Vicat apparatus for determination of water for the normal consistence paste

Figure 10. The resulting proofs

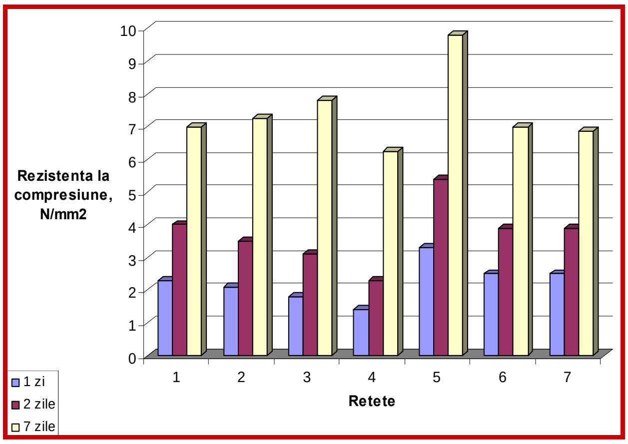

Figure 11. The resistance to pressure variation of cement proofs

Tab.6. The quality characteristics for our cement recipes

Characteristics		Recipe no.						
		1	2	3	4	5	6	7
Water for the normal consistence paste, [cm^3]		75	74	73	65	67,5	67	66
The binding time, [min]		16	19	14	13	15	18	18
Resistance to pressure, [N/mm^2]	1 day	2,30	2,10	1,80	1,40	3,30	2,50	2,50
	2 days	4,00	3,50	3,10	2,30	5,40	3,90	3,90
	7 days	7,00	7,25	7,81	6,25	9,80	7,00	6,87

The experiments meant to determine the amount of water in the normal consistency paste and of the binding start time have been done in the laboratories of the Faculty of Engineering of Hunedoara, using a Vicat apparatus, shown in *fig.9 and fig.10. We mention that the determinations were done according to all the norms in force. The data we obtained are given in tab.6 and in fig. 11.*

The resistance to compression has been tested by means of the device shown in fig.12, existing in the testing laboratories of CARPATCEMENT HOLDING Deva branch.

Figure 12. Compressing testing machine for cement sample. 1 – machine bench; 2 – test specimen; 3 - panel.

CONCLUSION

The resulting experimental data have lead to the following obvious conclusions:

- *the resistance to pressure of the cement test samples, where part of the clinker has been replaced by siderite waste, is comparable to that of regular cements;*
- *the specific surface has a high influence upon the resistance to pressure and one can see that the larger the specific surface, the larger the resistance to pressure.*
- *the resistance to pressure of experimental cements increases with time, so that one can notice that, after 7 days, resistance is 3 times higher than the resistance determined after 1 day;*
- *the highest resistance to pressure after 7 days was obtained for recipe no. 5, to which we added 25% siderite waste;*
- *particular attention should be paid in further researches to the fine grinding of cement, so as to obtain a specific surface above 3000 cm^2/g;*
- *the quantity of water for the normal consistency paste is smaller than the one usually recommended for cement: 70-90 cm^3;*
- *the binding start time obtained in laboratory conditions recommends the use of experimental cements for road leveling layers, as they harden fast (with a higher addition of water).*

At present, the acquisition price of cement is about 115€/t, out of which 22€/t represents the value of raw materials. The partial replacement of clinker by siderite waste leads to about 21% cut down on raw materials (the calculation referring to recipe 5, which has the best characteristics), respectively 4% of the price of cement.

Moreover, one has to consider the ecological impact, resulted from the removal of the waste ponds.

ACKNOWLEDGMENT

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Beneficiary: Balkan Environmental Association (B.EN.A.) – TUBORG,

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