EMERGEMAT

3rd International Conference on Emerging Technologies in Materials Engineering
29-30 October 2020 - Bucharest, Romania

Potential use of pyrite waste as cement replacement

Măcărescu Ionuţ[1,2], Anasiei Ioana[1,2], Vitan Nicoleta[1,3] , Ghiţă Mihai[1] , Matei Alexandru[1,2]

[1]National Research&Development Institute for Non-ferrous and Rare Metals – IMNR, , 102 Biruinței, Pantelimon, Ilfov, 077145, Romania ,
ionutmacarescu@yahoo.com, ianasiei@imnr.ro, mihai@imnr.ro, nvitan@imnr.ro, alex.matei@imnr.ro
[2]University Politehnica of Bucharest, Faculty of Materials Science and Engineering, 313 Splaiul Independentei, Bucharest, 060042, Romania
[3)]University Politehnica of Bucharest, Faculty of Applied Chemistry and Materials Science, 1-7 Gheorge Polizu, Bucharest, 011061, Romania

Abstract: This work presents stages of characterization and processing of iron mining waste in order to determine the capitalization potential as a secondary raw material resource in the cement industry. The iron mining waste inclusion in the composition of cement, as an addition material, has the following benefits: reduction of stored mining waste volumes, reduction of risk formation of acidic water and soils, reduction of CO_2 emissions in the atmosphere, reduction of electricity consumption in clinker production.

Experimental stages: Physico-chemical and mineralogical characterization, advanced wet grinding (attrition), extraction of sulphur from pyrite by oxidation in alkaline media at moderate temperatures and pressures and oxidizing agent - air, elaboration of mortar recipes at different ratios of cement replacement, preparation / storage / testing of mortar specimens according to SR EN 196/1 standard.

Physico-chemical and mineralogical characterization

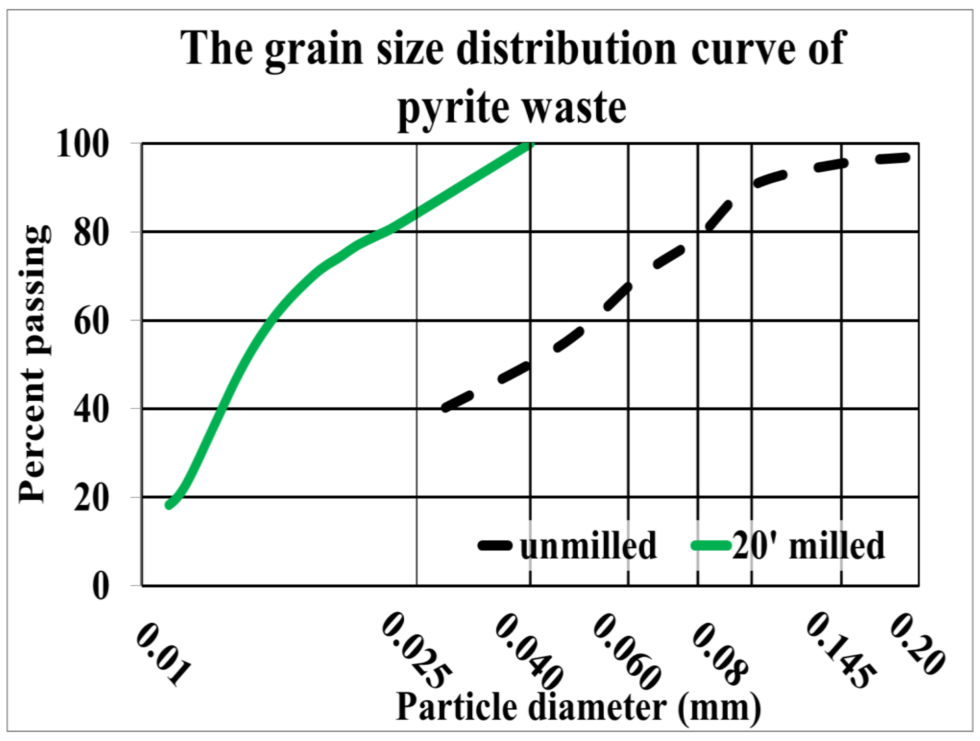

Figure 1. Considering the particles size, the initial material is characterized of D_{90} = 100µm, Φ_{mean} = 52 µm. The mechanically activated material is characterized of D_{90} = 25µm, Φ_{mean} = 15 µm.

Table 1. Chemical composition of the sulphate mining wastes before and after oxidation

	Chemical composition (%) of pyrite waste before and after hydrometallurgical									
	Mg	Al	Si	S	Ca	Fe	Cu	Zn	As	Pb
before	0.02	0.23	6.25	41.30	0.79	34.92	0.39	0.18	0.25	0.71
after	0.06	0.57	14.11	1.05	0.43	37.68	0.52	0.15	0.30	1.00

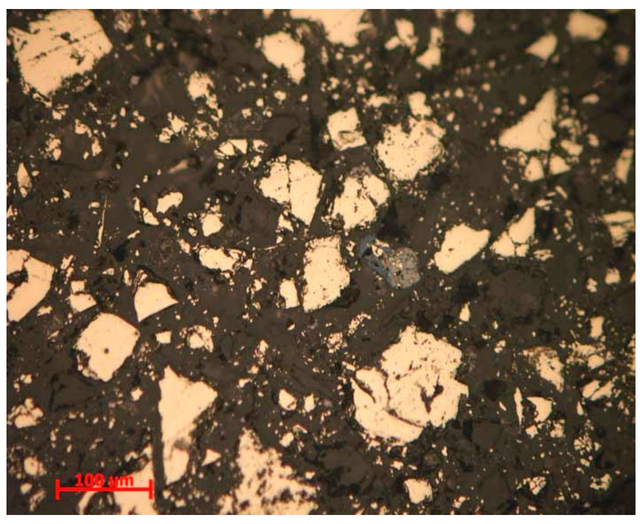

Figure 2. Reflected light, parallel Nicols. Pyrite, sphalerite, covellite, bornite.

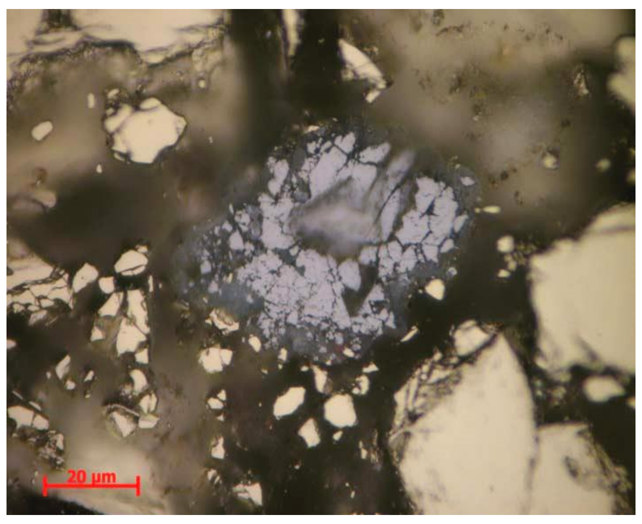

Figure 3. Reflected light, parallel Nicols. Pyrite, galena.

Table 2. The microscopy study

Mineral	Chemical formula	Proportion (%) calculated
Pyrite	FeS_2	74.53
Chalcopyrite	$CuFeS_2$	0.38
Covellite	CuS	0.20
Sphalerite	ZnS	0.27
Bornite	Cu_5FeS_4	0.21
Galena	PbS	0.82
Anorthite	$Ca(Al_2Si_2O_8)$	1.18
Quartz	SiO_2	12.88
Other minerals		9.53

Elaboration and preparation of mortar specimens

The reference mixture (100% Portland cement) consisted of cement (450g), standardized sand (1350g) and water (225g).
In other blends, Portland cement was partially replaced by oxidized pyrite at 15 – 50% from cement weight. For all mortars, the water/binder coefficient was 0.5. After 24 hours of casting the specimen were demolded and submerged in water curing tank until the age of testing.

Figure 4. Mortar recipe mixer

Figure 5. Vibrating table for sample compaction

Figure 6. Water tank for storing samples

Figure 7. Testing machine for measure compressive strength.

Figure 8. Testing machine for measure flexural strength.

Results

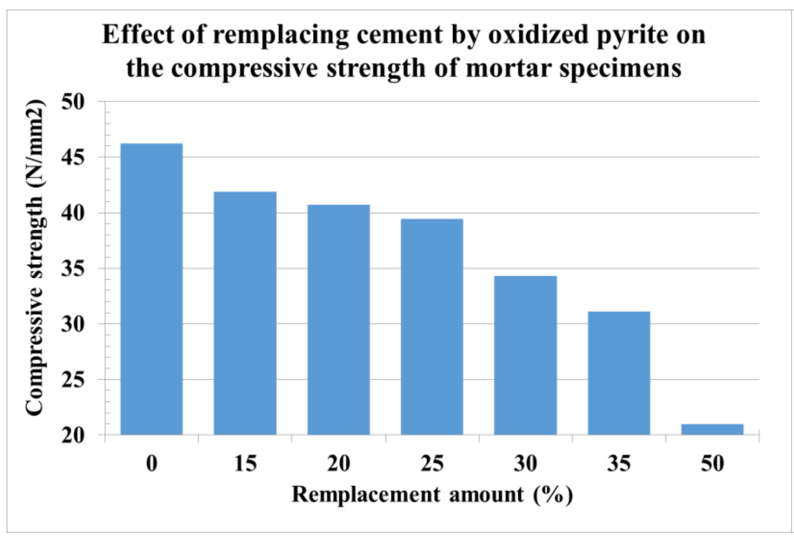

Figure 9.

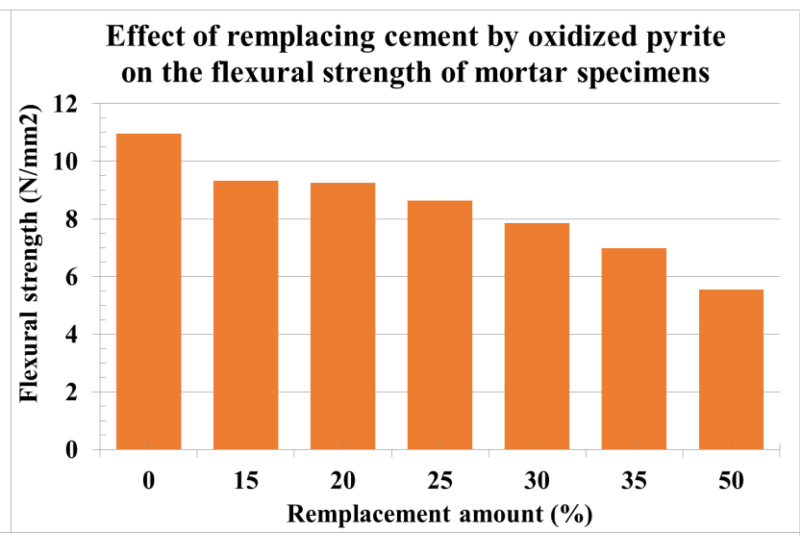

Figure 10.

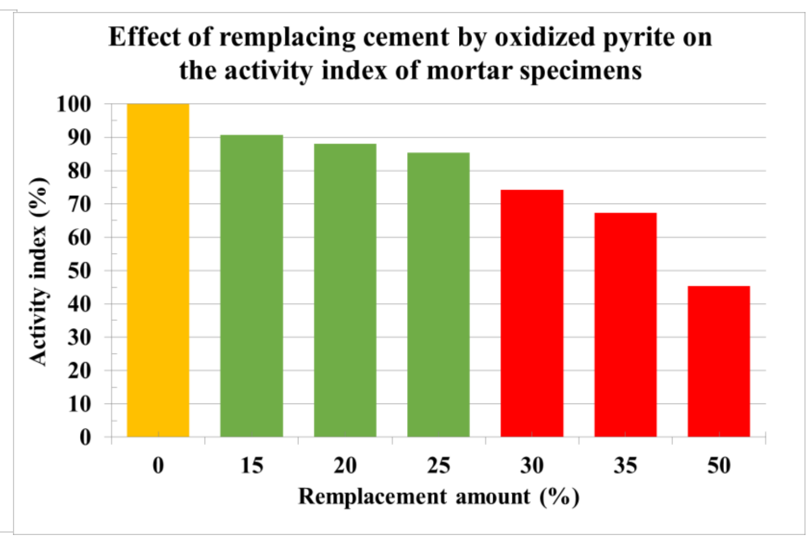

Figure 11.

The figures 9, 10, 11 shows the average of compressive/flexural strength and activity index test results of mixtures measured at 28 days. Each data is an averages of three test measurements. The results obtained indicate that the compressive strength of all mixtures showed a similar behaviour, as that of flexural strength and activity index results. The effect of the replacement of the Portland cement by oxidized pyrite is the reduction of: (1) the compressive strength from 41.90 N/mm² (maximum at 15% replacement amount) to 21.98 N/mm² (minimum at 50% replacement amount); (2) the flexural strength from 9.34 N/mm² (maximum at 15% replacement amount) to 5.55 N/mm² (minimum at 50% replacement amount); (3) activity index from 90.68% (maximum at 15% replacement amount) to 45.40% (minimum at 50% replacement amount).

Conclusions

The mixture with 20% replacement amount seems to be the optimum replacement in the investigation.
The predominant chemical composition: pyrite waste - S 41.30%, Fe 34.92%, Si 6.25%; oxidized pyrite - S 1.05%, Fe 37.68%, Si 14.11%.
The oxidized pyrite replaces binders (cement) up to 20%-50%wt, fact that showed a lowest (~30%-50% that control mix) compressive/flexural strength and activity index after 28 days of curing.