Iron-silicate fines (ISF)

Aurubis

CHARACTERISTICS OF IRON-SILICATE FINES AS REPLACEMENT MATERIAL IN CEMENT CONCRETE

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From waste materials to concrete admixtures

Concrete is the most widely used construction material in the world[1]. It is a homogeneous composite, which contains heterogeneous materials:

- binder - mostly cement;
- aggregates (both sand and gravel) (70% of the volume of concrete);
- water;
- chemical additives.

8-12 mill.t/y 2

Quarry for aggregates (fine and coarse)

Main reasons for utilizing industrial waste in concrete and mortar as fine aggregates or substitutes for cement:

- counteracting the decrease of natural resources;
- reducing the cost of construction materials;
- solving the problem of disposal of waste materials, generated by different industries;
- improving the properties of composite materials – both in fresh and hardened state.

Industrial waste are used as a mineral admixtures in the form of:

- blended cements or
- added directly as admixtures to the fresh concrete mix at the time of mixing.

Industrial wastes also called “Mineral Admixtures” or ‘Supplementary Cementing Materials’ and can be divided into two groups:

- cementitious materials - have cementitious properties by themselves.
- pozzolanic materials - exhibit cementitious properties when combined with calcium hydroxide (lime).

Commonly used mineral admixtures, obtained by different types of industrial production, to partially or fully replace cement or sand in concrete and mortar production are:

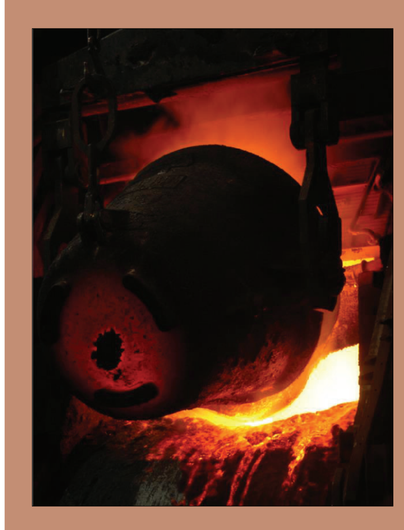
- steel slag,
- blast furnace slag,
- ground granulated blast furnace slag
- coal bottom ash,
- fly ash,
- silica fume,
- metakaolin
- copper slag,
- iron-silicate fines,
- waste foundry sand,
- imperial smelting furnace slag, etc.

Different kinds of mineral admixtures

Most of these wastes are well-known and successfully applied in the concrete industry, except for iron-silicate fines, which are relatively unknown in practice.

Characteristics of iron-silicate fines as a fine aggregate in concrete

Iron-silicate fines (ISF) are a waste material, generated by flotation of copper slag (both by furnaces and convertors) during the metallurgic production process in the copper plant of Aurubis Bulgaria.



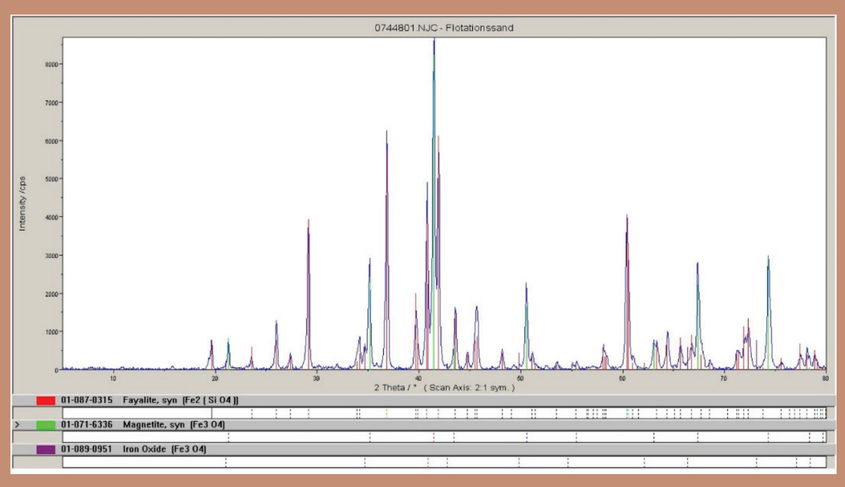
Pouring of hot copper slag

Bulk iron-silicate fines

Chemical composition of iron-silicate fines

Element	Typical content	Range
Fe	46.0 %	(44 ÷ 48) %
SiO_2	27.0 %	(26 ÷ 28) %
Al_2O_3	3.2 %	(2.7 ÷ 3.7) %
CaO	1.8 %	(1.3 ÷ 2.5) %
MgO	0.7 %	(0.6 ÷ 1.1) %
Cu	0.42 %	(0.36 ÷0.48) %
S	0.36 %	(0.25 ÷ 0.55) %

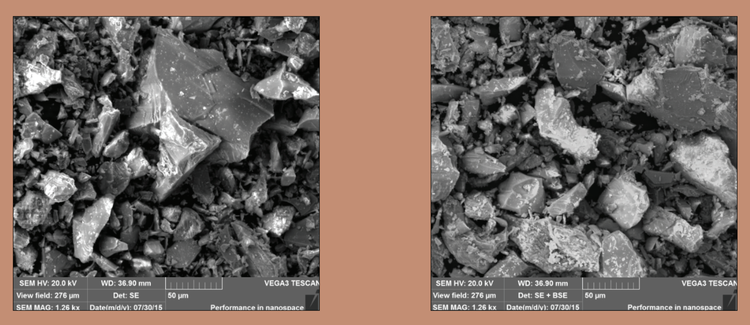
X-ray diffraction pattern of iron-silicate fines



ISF contain mostly ferrous and silicate oxides (Fe_2O_3 in the form of fayalite (Fe_2SiO_4) and magnetite (Fe_3O_4)), together with smaller quantities of aluminium, calcium and magnesium oxides.

Copper plant of Aurubis, Bulgaria with the storage place for iron-silicate fines

The material has dark angular particles with rough texture and irregular shape. These physical characteristics of ISF reflect positively on adhesion with other aggregates in concrete.



SEM of iron-silicate fines

ISF have physical properties similar to the ones of the fines used in concrete and mortar production.

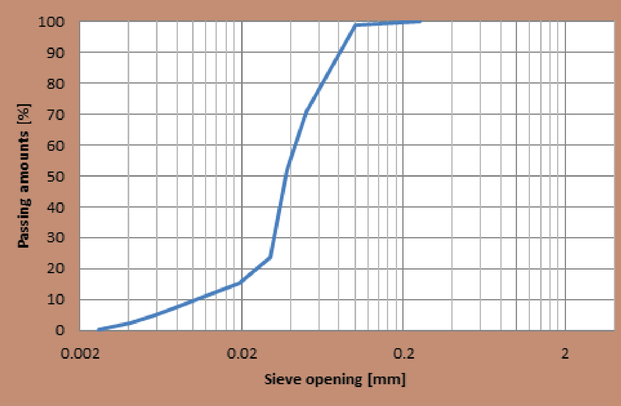
Density of ISF:

- The specific density, based on BNS EN 1097-6, is found to be 3.8 g/cm³, which is close to the densities of 3.91 g/cm³, reported by other copper slag producers[3,4].
- The loose bulk density, according to BNS EN 1097-3, is determined to be 1.83 g/cm³, which is relatively high for this type of material. This is due to the heavy weight of ferrous oxides in the composition and the smaller grain size compared to other kinds of copper slags generated by the industry, but also to all kinds of wastes in general.

The particle size distribution of ISF:

- 75% particles between 0.0383 mm and 0.05 mm and
- 24% smaller particles with size between 0.0041 mm and 0.0383 mm. .

Particle size distribution of iron-silicate fines



Conclusions

The physical and chemical characteristics of ISF do not differ from those of other waste materials used in concrete production, which makes it a perspective material in that field of application. As a new material, it should first be tested in a laboratory and then on an industrial scale. Different tests related to sand and cement substitution will prove the presence or absence of pozzolanic activity of ISF. The use of ISF in concrete will open up new undiscovered areas of their application and will partially solve the problem of their deposition.

References

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