Table 4: Slump and compressive strength of concrete using BIO

Portion (M/C*%)	Slump (cm)	Compressive strength (kg/cm^2)				
		7-days	28-days	96-days	6-mon.	1-year
0	8	360	375	385	395	390
0.5	7	440	450	450	470	500
1	8.5	440	460	470	480	510
1.5	9.5	410	420	400	450	455
2	12	390	405	430	470	480
2.5	13	380	400	420	420	430

*M/C = amount of iron oxide in grams (M) / amount of cement in grams (C)

BIO produce approximately linear behavior of slump increasing, this fashion illustrated in Fig. 1, the maximum increasing of concrete slump, which is 13cm, produced by 2.5% portion. Detectable increasing in the concrete compressive strength using BIO as admixture, this increasing comes to be in maximum value at 1% portion at one year age, Fig. 2, outline the pattern of concrete compressive strength using BIO.

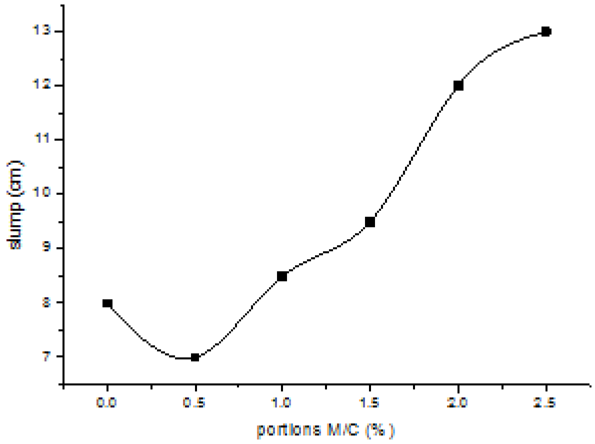

Figure 1: Effect of BIO on the concrete slump

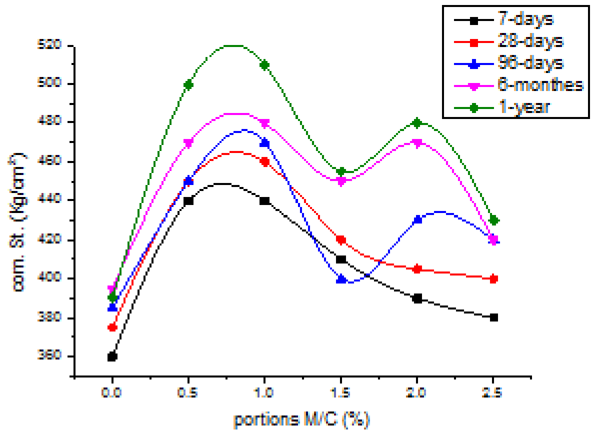

Figure 2: Compressive strength of concrete using BIO with different ages

3.2. Red iron oxide

In case of red iron oxides (RIO), the following table will outline the results of slump as well as compressive strength of concrete using (RIO):

Table 5: Slump and compressive strength of concrete using RIO

Portion (M/C*%)	Slump (cm)	Compressive strength (kg/cm^2)				
		7-days	28-days	96-days	6-mon.	1-year
8	360	375	385	395	390	8
6	340	350	355	355	360	6
11	320	335	340	350	350	11
9	360	380	390	400	400	9
12	370	385	390	410	420	12
12.	380	395	400	420	440	12.

RIO make a unique curve which alternating between increasing and decreasing of concrete slump using different portions, this fashion is outline in Fig. 3.

RIO shows relatively small increment in the concrete compressive strength at different ages according to Fig. 4, and this increment in maximum at 2.5% portion for 1-year age.

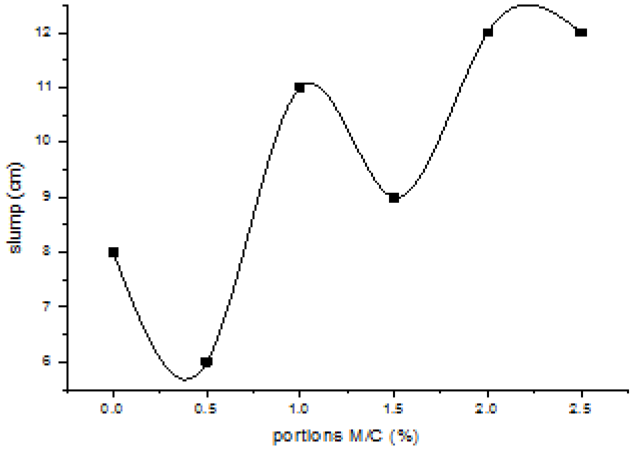

Figure 3: Effect of RIO on the concrete slump

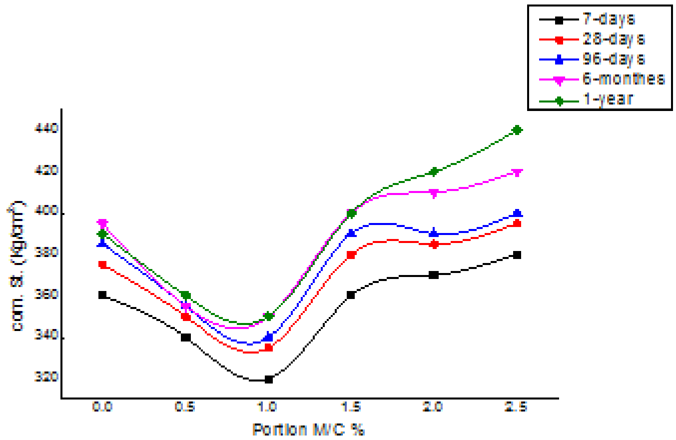

Figure 4: Compressive strength of concrete using RIO with different portions at different ages

In general there are increase in workability as well as increase in compressive strength, but the optimum portion addition shifted from 1% in case of BIO to be 2.5% for RIO.

Iron (II, III) oxide (black iron oxide) is a chemical compound with formula Fe_3O_4. It contains both Fe^{2+} and Fe^{3+} ions and sometimes formulate as $FeO \cdot Fe_2O_3$. This composition give black iron oxide opportunity to be more reactive than Fe_2O_3 (red iron oxide) spatially at media like concrete media.

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As ***[4]***, postulate in their work, which pointed in brief in the binging of this article, when surface of iron oxides is covered with OH^- ions attached to Fe III ions, these species are called surface functional groups and contribute substantially to the specific adsorption of various anions as inner sphere complexes. Common sorbates are phosphate, silicate, arsenate and sulfate, as well as cations such as heavy metals, or calcium in concrete environment. This adsorption makes the Fe environment act as an efficient sink for these ions thereby restricting the electrostatic interactions.

Surface adsorption operates through Fe–OH groups at the surface of Fe-oxides and results from the completion of the ligand shell of surface Fe atoms. These groups attain negative or positive charge by dissociation or association of protons, depending on the pH of the surrounding.

$$=FeOH \longrightarrow =FeO^- + H^+ \text{ (Dissociation).}$$

$$=FeOH + H^+ \longrightarrow =FeOH_2^+ \text{ (Association).}$$

Furthermore, these complex processes are affected by the presence of other ions, such as Ca^{2+}, both of which serve as an electrolyte, which combine with the hydroxides and oxides of iron to precipitate a variety of Ca-Fe-O-OH species.[10]

From the above discussion, BIO and RIO act as retarder through inhibiting the ionic reactions occur in the concrete environment at early age, which inflect as increasing in the workability of concrete.

On the other hand, the presence of different oxidation states of iron in BIO may promote the formation of different phases in the Ca-Fe-O-OH moiety, which explaine the compressive strength increases. There are some evidences support the above approach as

- By increasing, the percent of BIO, at percentage above 3% the concrete start to segregate, that mean the binding action of cement started to inhibit.
- The maximum increasing of compressive strength for BIO achieved at 1% for different ages, but the slump increases by portions of BIO increase, which enhances the assumption of surface adsorption at the surface of Fe-oxides.
- We tend to make simple experiment to explain the action of Ca-ion in the mixture, by testing the concrete included 5% of calcium carbonate, and then test this concrete by adding 1% BIO.

The result of this experiment is out lined in the Fig.5, which indicate that BIO modify the compressive strength of that concrete using calcium carbonate, which may indicate the formation of phases that enhanced the compressive strength. As well as the slump increases from 10cm to 13cm, which may support the surface adsorption assumption.

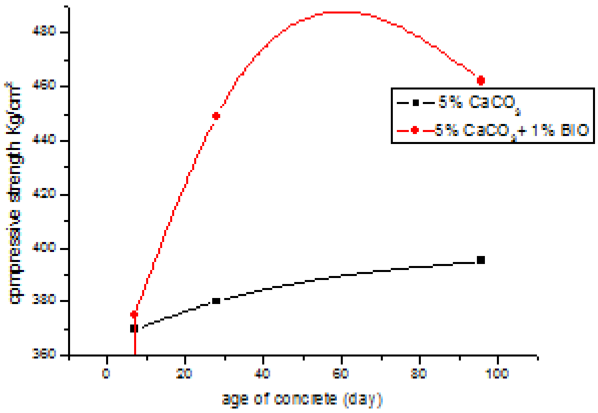
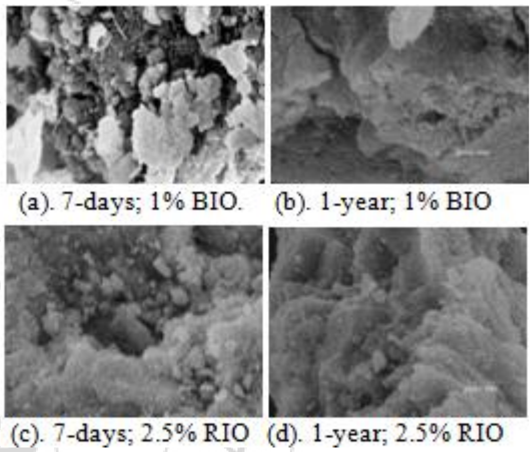


Figure 5: Effect of combination between BIO and calcium carbonate on concrete

SEM images may give additional clarification of the situation that achieved using iron oxides on concrete as admixtures as follow:



The above SEM-images are clearly show the formation of CH phase at 7-days while at 1-year the C-S-H phase is a predominate one, in both cases of RIO and BIO.

The composition of the cementitious material in concrete can have a significant influence on the behavior of all chemical admixtures. Inasmuch as these admixtures affect the early stages of hydration, and are at least partly removed from solution by the early reactions, the cement phases that react most rapidly have a large influence on their action. The early reacting compounds include C3A and the alkali and calcium sulfates.[11]

This is clearly appear through the following Fig.6, of XRD-pattern of BIO as well as RIO, in the comparison with M0 (blank or control), and sand that used throughout this study.

The hydration of the cement components results are the conversion of C_3S and β-C_2S into the hydration products, calcium silicate hydrate (CSH) and calcium hydroxide (CH) as shown in above Fig.6. Accordingly, the intensity of the characteristic peaks of the reactants such as alite and belite phases decreases with increasing the hydration age.

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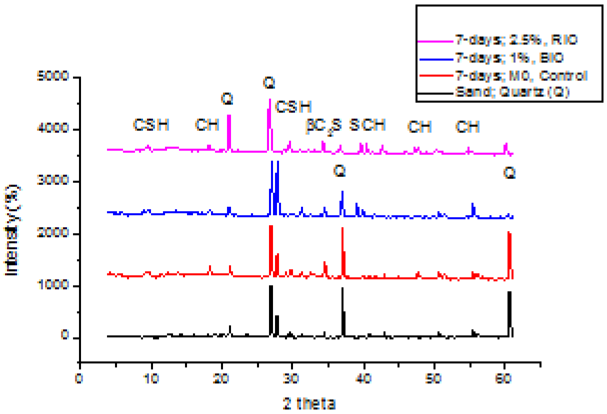

Figure 6: XRD-patterns of BIO and RIO, in the comparison with M0 (blank or control), and sand

4. Conclusion

From the obtained results it can be concluded that:

1) For BIO 1% is the optimum percent, it increase the slump 6.25% and the compressive strength by 22-30%. So it can be used as mineral admixture.
2) For RIO 2.5% is the optimum percent, it increase the slump 50% and the compressive strength by 5-3012%. So it can be used as retarder.

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Author Profile

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