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The Effect of Different Mineral Admixtures on Characteristics of Concrete

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Abstract

This paper presents a review of the properties of fresh and hardened concrete by using mineral admixtures fly ash (*FA*), and silica fume (*SF*). In many countries, these materials are already used in manufacturing of concrete. However, these industrial by products is becoming popular throughout the world because of the minimization of their potential hazardous effects on environment. Some of these materials used as replacement for cement. Ultimately it results in the reduction of the cost manufacturing of concrete and reduces environmental pollution. In general, small particle size and higher specific surface area of mineral admixture are favorable to produce highly dense and impermeable concrete; however, they cause low workability and demand more water. To study the effect of mineral admixtures such as fly ash and silica fume on mechanical properties of concrete under the uniaxial compression experimental studies conducted. The cement was replaced by 10 %, 20 % and 30 % with fly ash and silica fume. The compressive strength test conducted on concrete specimen with different percentages of fly ash and silica fume at age of 7 days and 28 days.

Keywords: Slump, compressive strength, fly ash, silica fume.

1. Introduction

Concrete structure is the most common type of structure, and it keeps developing and improving day after day to meet the global and environmental requirements, this structure is basically a mixture of cement, water, sand, and coarse aggregate. However, cement considered as the most expensive and significant ingredient in concrete production. Concrete is the major structural material widely consumed in the world, after water. Most of the infrastructure and building construction in Libya are using concrete as construction materials. On the other hand, concrete has growing popularity in Libya and most of cement used in Libya is Portland cement. The term "Portland Cement" pertains to a calcium silicate hydraulic cement produced by heating materials containing calcium, silicon, aluminum, and iron.

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Therefore, Portland cement is also one of the topmost consuming industries in the world. With the increase demand on construction materials, the cost for the construction affected. So, the cost of construction materials has become serious problems today. Many countries around the globe are facing this cement shortage problem from time to time. However, cement is made by combining a mixture of limestone and clay in a kiln at 1450 °C [1]. The product is an intimate mixture of compounds collectively called clinker. This clinker is finely grounded into a powder form. The raw materials used to make cement is compounds containing some of the earth's most abundant elements, such as calcium, silicon, aluminum, oxygen, and iron. However, Pozzolanic materials are either natural or artificial such as fly ash and silica fume have gained acceptance as mineral admixture and or cementation replacement materials in many parts of the world.

Admixtures will add in concrete to improve the concrete quality. Mineral admixtures include fly ash (*FA*), silica fume (*SF*), rice husk ash (*RHA*), ground granulated blast furnace slag (*GGBS*), and metakaolin (*MK*) which have certain characteristics through which they influence the properties of concrete differently. The reported benefits of mineral admixtures are often associated with the harden properties of concrete; however, mineral admixtures may also influence the properties of wet concrete between the time of mixing and hardening in one or more of the following ways such as they may affect water demand, heat of hydration, setting time, bleeding, and reactivity [2-5].

There is no literature that summarizes the effect of these mineral admixtures on the properties of fresh concrete. Furthermore, effect of mineral admixtures on the durability and on the mechanical properties of concrete remained a focus of interest. However, effect of mineral admixtures on the properties of fresh concrete is very important as these properties may affect the durability and mechanical properties of concrete. This paper written to offer the reader with a distinctive comparative analysis on the effect of mineral admixtures on workability and hardened of concrete.

2. Materials

This work consists of casting, curing and testing of concrete specimen with varying percentages of fly ash and silica fume at different ages.

2.1. Portland cement

In this experimental study, Ordinary Portland Cement (OPC) conforming to IS: 8112-1989 used for making concrete; it was fresh and free from lumps.

2.2. Coarse aggregate

Crushed stone aggregates used. The maximum size of the aggregate is 20 mm used in the experiment. The coarse aggregates were dry.

2.3. Fine aggregate

The fine aggregates used in the experiment collected from local available natural sea sand. Specific gravity of fine aggregates was 2.62. The fine aggregates were dry.

2.4. Water

Clean drinking fresh water, free from impurities used in the mixes. Water-cement ratio was 0.67 by weight.

2.5. Mineral admixtures

2.5.1. Fly ash

Fly ash, known also as pulverized–fuel ash, is the ash precipitated electro-statically from the exhaust fumes of coal-fired power stations, and is the most common artificial pozzolana. In this investigation work the fly ash used from Sika Company. The chemical analysis and physical properties of fly ash are shown in Table 1.

Table 1: Chemical analysis and physical properties of fly ash.

Chemical Analysis	**Mass %**
Silica (SiO2)	47.0-55.0
Aluminium (Al2O3)	25.0-35.0
Iron (Fe2O3)	3.0-4.0
Manganese (Mn2O3)	0.1-0.2
Calcium (CaO)	4.0-10.0
Magnesium (MgO)	1.0-2.5
Phosphorus (P2O5)	0.5-1.0
Potassium (K2O)	0.5-1.0
Sodium (Na2O)	0.2-0.8
Titanium (TiO2)	1.0-0.5
Sulphur (SO3)	0.1-0.5
Loss on Ignition (LOI)	0.5-2.0
Specific Surface Area (cm2/g)	8500
Specific gravity	2.6

2.5.2. Silica fume

Silica fume is a by-product resulting from reduce high-purity quartz with coal/coke in an electric arc furnace during produce Silicon metal/Ferro-silicon alloys. In this investigation work the Silica fume used from Sika Company. The chemical analysis and physical properties of silica fume are shown in Table 2.

Table 2: Chemical analysis and physical properties of silica fume.

Analysis and properties	**Mass %**
SiO2	90.2
Al2O3	1.7
Fe2O3	0.4
CaO	2.1
MgO	1.7
Na2O	0.7
K2O	0.7
SO3	0.5
Loss on ignition (LOI)	2.5
Specific Surface Area (cm2/g)	200000
Specific gravity	2.21

2.6. Mix proportion of specimen

This study will focused on normal strength concrete with strength grade 20 MPa at 28 days. Twenty four specimens with dimension 150mm × 150mm × 150mm fabricated in the Structural Engineering Laboratory of Bani waleed University Libya. Nevertheless, water cement ratio is (w/c 0.67), the Ordinary Portland Cement (OPC) used as binder, 20 mm crashed stone as coarse aggregate , sea sand, and mineral admixtures (fly ash , silica fume) One control mix equipped without the use of any admixture. Slump test used to assess the workable of the concrete mixes. Compressive strength used to figure on concrete cubes at 7, and 28 days. All samples for hardened concrete tested cured in water at temperature of 27 + 2ºC [6-7]. Six cubes used for each concrete mix. The concrete poured into the mould in two layers where each layer compacted using a steel bar free hand fall for 25 times. And the cubes removed from the moulds after 24 hours and cured using large open water tank.

3. Results and discussion

3.1. Fresh properties

The slump results shown in Table 3 and Figure 1 for ordinary Portland cement mixtures, the mixtures containing silica fume had the lowest slump. This is due to high surface area of silica fume particles which have higher water demands than the mixtures with fly ash. The mixtures containing fly ash had higher slump results because of the spherical shaped particles which reduce the interparticle friction. The slump values increased as ratio of replacement increased from 10%, 20%, and 30% for fly ash. However, when increase the ratio of Silica fume mixtures had almost equal slump values for control mix.

Table 3: Results obtained from slump test.

Mixed	Slump (mm)			
	0 min	30 min	60 min	90 min
OPC (control mix)	10	0		
10% FA	20	5	0	
20% FA	50	15	8	0
30% FA	60	13	12	0
10% SF	19	10	6	0
20% SF	18	8	0	
30% SF	7	5	0	

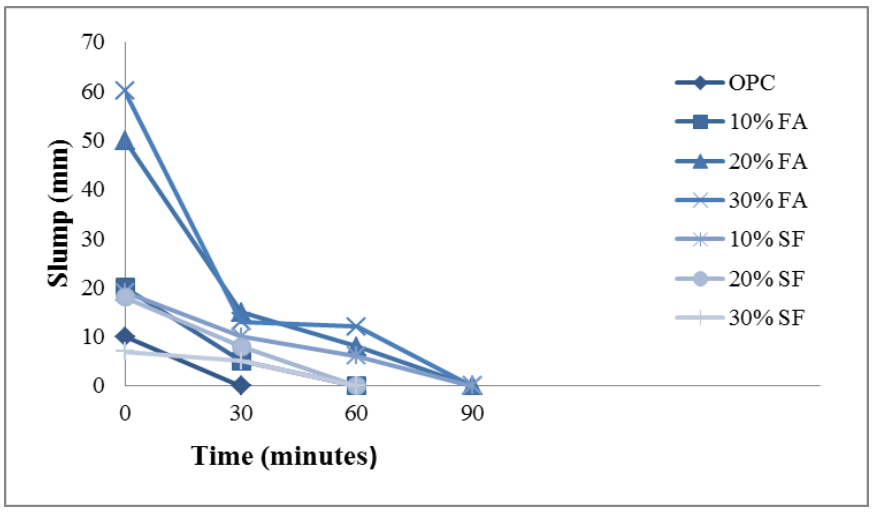

Figure 1. Results of slumps.

3.2. Hardened properties

Compressive strengths of concretes compared to OPC concrete in Table 4 and Figure 2. The compressive strength at 7 days of OPC concrete was 22.66 N/mm^2. Compressive strength of 10% FA, 20% FA, 30% FA concretes were 20.88, 19.11, 16.68 N/mm^2 respectively. Likewise, the compressive strength at 28 days of OPC concrete was 28.97 N/mm^2. Compressive strength of 10% FA, 20% FA, 30% FA concretes were 29.15, 27.96, 23.76 N/mm^2 respectively. At higher replacement ratio 30% FA, for both curing time the strength of concrete lowest since the amount of Portland cement was greatly reduced. For series of SF concretes the compressive strengths at 7 days of 10% SF, 20% SF, 30% SF concretes were 18.66, 15.50, and 12.88 N/mm^{2,} respectively. Likewise, for 28 days series of SF concretes the compressive strengths of 10% SF, 20% SF, and 30% SF concretes were 26.62, 22.54, and 18.59 N/mm^{2,} respectively. Again, increasing in replacement ratio of SF, the compressive strength of concrete reduced. %10 SF had higher compressive strengths because Silica fume is much finer for both ages 7 and 28 days. As a result of the higher surface area the pozzolanic reaction proceeds rapidly and strength is quickly developed. From this investigation the recommended that blending of silica fume and fly ash is not essential to increase the strength characteristics of concrete. Either silica fume or fly ash alone is enough to enhance the quality.

Table 4: Results of compressive strength.

Mixed	Slump (mm)			
	0 min	30 min	60 min	90 min
OPC (control mix)	10	0		
10% FA	20	5	0	
20% FA	50	15	8	0
30% FA	60	13	12	0
10% SF	19	10	6	0
20% SF	18	8	0	
30% SF	7	5	0	

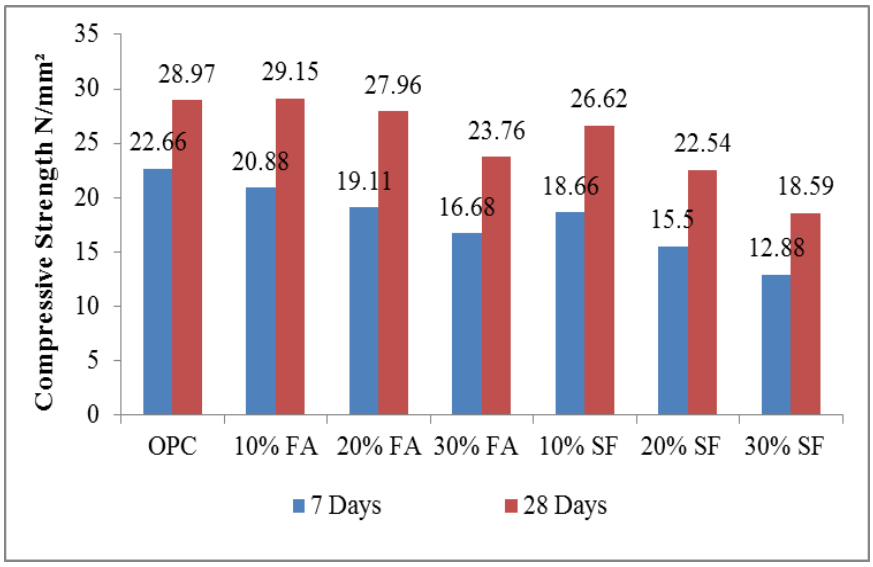

Figure 2. Results of Compressive strength.

4. Conclusions

The following conclusions are drawn from the experimental investigation:

1. The replacement materials fly ash and silica fume are suitable for manufacture of concrete.
2. The percentage of Fly ash and Silica fumes in the mix will affects the workability.
3. It was also observed that addition of fly ash to concrete leads to improvement in compressive strength of concrete.
4. The replace of cement by fly ash results in improving the workability up to a replacement level of 30 %.
5. It concluded that silica fume concrete attains low early ages strength as compared to normal concrete. But the rate of development of strength is more at later stages.
6. It was found that levels of replacement of cement by fly ash is around 10% and 20% as the strength shown by fly ash cement at the replacement level is nearly equal to strength shown without fly ash concrete at 28 days.
7. It was found that levels of replacement of cement by silica fume for 10% shown strength by silica fume cement at the replacement level is nearly equal to strength shown without silica fume concrete at 28 days.

References

[1] ASTM C593- 95. "West Conshohocken, PA: American Society for Testing and Materials".
[2] Malhotra, V.M., Proceeding 1st international conference on the use of Fly Ash, Slag, Silica fume and other material by product in concrete 1983.
[3] Reshi S.S and Garg, S.K., "Proportioning concrete containing fly ash", the IEI journal, 1964, vol.45.
[4] Zhang M.H and Malhotra, V.M., "Making concrete greener with Fly ash", Indian Concrete Journal, Oct 1999, pp 609-615.
[5] ACI Committee 211, "Guide for selecting proportions for HSC with Portland cement and fly ash", ACI material journal vol-90, No.3. 1993, pp 273-283.
ACI Committee 363, "State of art report on high strength concrete", ACI Journal, Vol- 81, No.4, 1984, pp366-411.
[6] British Standard Institution, BS 1881: Part 102 (1983). "Methods for Determination of Slump".
[7] British Standard Institution, BS 1881: Part 116 (1983). "Methods for Determination of Compressive Strength of Concrete Cube".