

Effect of Calcined and Non Calcined Fly Ash Addition on The Strength of Concrete

اثر اضافة الرماد المتطاير المحروق وغير المحروق على متانة الخرسانة

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Abstract:

The present work studies the effect of calcination of the fly ash that added to the concrete to enhance its strength. The fly ash added to the concrete batch in different weight ratios 20, 25, and 30 %. The fly ash added in two groups, group1: Fly ash without firing (Calcination) with particle size ranging from 0.425-1.18 mm. while group 2: Fired (calcined) fly ash at 700 °C for 4 hours. The X-ray diffraction for calcined fly ash shows that the organic compound shown in the non calcined fly ash was disappeared and the main compounds was silica and millite. Slump test was achieved for the fresh concrete with the addition of calcined fly ash, which shows a clear reduction. The absorption of water during curing was reduced by calination the added fly ash. Also the strength of concrete was enhanced in the case of calcination the added fly ash more than in the case of adding non calcined fly ash.

Key Words: Concrete, Calcined Fly Ash, Non Calcined Fly Ash.

الخلاصة:

البحث الحالي يدرس تأثير حرق الرماد المتطاير المضاف الى الخرسانه لتحسين مقاومتها. الرماد المتطاير المضاف الى خلطات الخرسانه يكون بنسب مختلفة 20, 25, و30%. ويكون الرماد المضاف بنوعين الاول بدون حرق ويكون الحجم الحبيبي يتراوح بين 0.425-1.18 ملم بينما النوع الثاني يكون الرماد المحروق بدرجة حرارية 700 درجة مئوية ولمدة 4 ساعات. فحص حيود الاشعه السينية للرماد بعد الحرق اوضح بزوال المركبات العضوية التي كانت موجودة بالرماد غير المحروق المركبات الاساسية الموجودة هي سليكا والملايت. اختبار الهطول اجري للخرسانه الطرية بأضافة الرماد المحروق تحسنت بشكل ملحوظ وقلت وكذلك الامتصاصيه خلال التخمر قلت بأستخدام الرماد المحروق. المقاومة ازدادت للخرسانة المضاف له رماد محروق اكثر من اضافة رماد غير محروق .

1. Introduction:

Concrete as is well known is a heterogeneous mix of cement, water and aggregates. The admixtures may be added in concrete in order to enhance some of the properties desired specially. In its simplest form, concrete is a mixture of paste and aggregates. Various materials are added such as fly ash, rice husk ash, and admixture with using steel fiber to obtain concrete of desired property. The character of the concrete is determined by quality of the paste. The key to achieving a strong, durable concrete rests in the careful proportioning, mixing and compacting of the ingredients. The detailed experimental investigation is doing to study the effect of partial replacement of cement by FA (fly ash) and its effect on the concrete strength [1].

The effect of fly ash on the concrete system is not only influenced by the morphology of the fly ash (including the presence of unburned carbon), But more so by the presence of fine spherical particles and the interaction with the particle size distribution of the cement used (packing density/filler effect. There is, however, another good reason why specification for fly ash (as extender or constituent in cement) limits the unburned carbon to 5%: during concrete compaction carbon will float to the surface because of the low density, and larger amounts can cause discoloration [2].

The appropriate use of fly ash can Improve rheological properties making it easier to pump, place & finish concrete, Increase the strength of concrete, Reduce permeability to water (& other fluids), Increase the resistance to chloride ions, Decrease the corrosion rate of embedded steel,

Increase the resistance to Sulphate attack Increase the resistance to acid attack, and Suppress deleterious expansion due to alkali-silica reaction (ASR) [3].

However, the performance of fly ash concrete is influenced by many factors such as, the type of fly ash (physical & chemical properties), the level of replacement used, the nature of the Portland cement (e.g. alkali content) and the quality of the concrete [4].

Fly ash concrete is designed in the same manner as Portland cement concrete. Generally lower water contents are required for a given slump. The slower strength gain usually associated with fly ash concrete requires that the water-to-cementing-materials ratio (W/C) has to be reduced to provide the same strength at early age (e.g. up to 28 days) as Portland cement concrete. Thus, use of fly ash usually results in lower water content and higher cementing material content than Portland cement concrete of the same strength and workability. The higher cementing material content and lower density of fly ash (compared with Portland cement) result in increased volume of powder, which means that the fine aggregate content can be reduced [5].

Fly ash concrete will be subjected and tested in the same manner as Portland cement concrete. In addition, to concrete tests, the fly ash source requires periodic testing to determine its properties and suitability for use in concrete [5].

Numerous tests are performed on wet concrete such as workability tests such as compaction factor test and slump test. The tests on hardened concrete are destructive test while the destructive test includes compressive test on concrete cube for size (150 x 150 x 150) mm, actual practice, test on workability of wet concrete are carried out to ensure uniform quality concrete only. Strength is not a measurable at that stage with the available technology. Therefore the concrete samples are to be cured for 28 days in normal method to arrive at the compressive strength and for necessary follow up action [6].

For mortar with the same flow, the drying shrinkage at early age was found to decrease with an incorporation of fly ash. The early shrinkage of the mortar with finer fly ash was a little larger than that of the coarser fly ash mortar [7].

Most of the recent studies involved in high strength concrete where highly depend on the quality of ingredient materials thus making it very costly and time consuming , this were achieved by adding fly ash in different percentages as a replacement of cement by fly ash due to improve slump, workability and some mechanical properties. [9]

The work presented in this paper reports an investigation on the behavior of concrete produced from blending cement with FA (without calcination and calcined fly ash) and compare between them.

2. Experimental work

2-1 Materials:

The materials used in the present work are listed in the following:

Cement: Iraqi Ordinary Portland cement (OPC) according to ASTM C150, Type I.

Aggregate: Gravel and sand as graded in Fig. (1) bellow.

Fly ash: The fly ash was obtained from south Baghdad Power station, which was classified into two groups.

Group 1: Fly ash without burning (calcination) with particle size ranging from 0.425-1.18 mm.

Group 2: Burn (calcined) fly ash at 700 0C for 4 hours with particle size distribution as shown in Fig.(2) bellow.

Tap water was used in the process for producing batches.

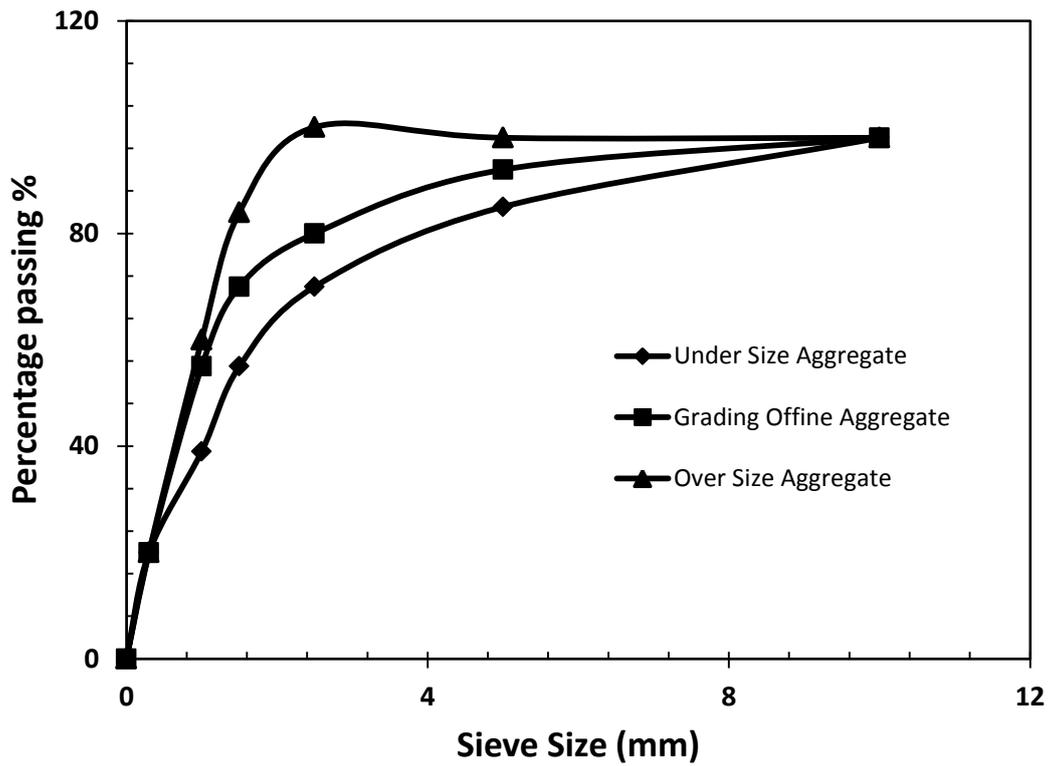


Fig.(1): Grading of sand and gravel used in the work

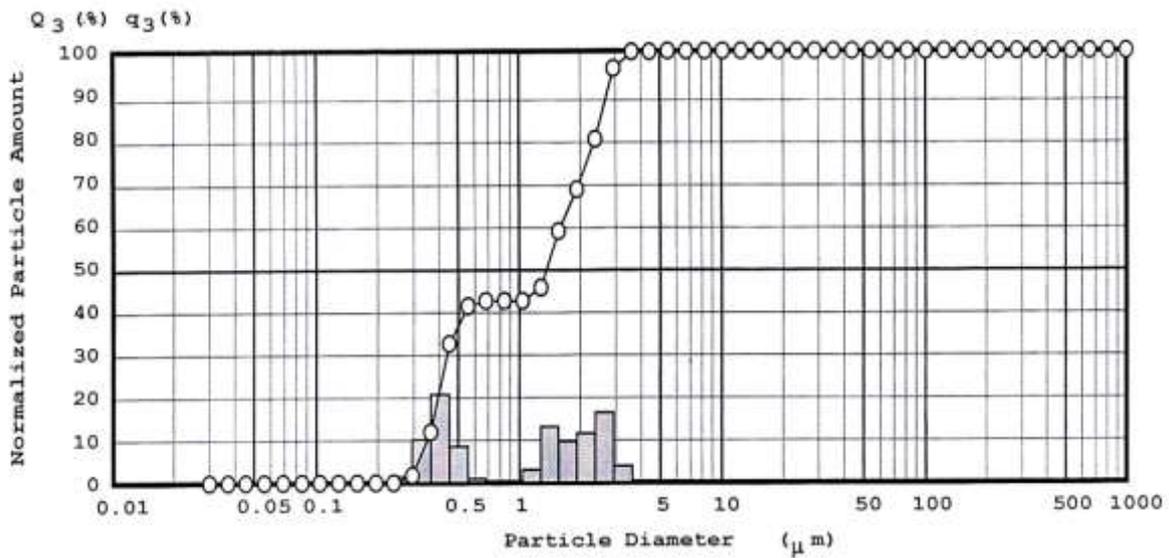


Fig.(2): particle size analysis for Calcined Fly Ash.

2-2 Methods:

The concrete prepared by mixing cement: sand and gravel with ratio 1:1.5 :3 by weight. The fly ash replacement level of 20, 25 and 30 % by weight of the cementations material was used for all the mortar mixes. This high level of replacement was selected such that the effect of the fly ash replacement could be detected. Three sampling test were studied, where three standard cubic for each sampling case were tested for ordinary concrete, concrete with non calcined fly ash and concrete with calcined fly ash as additive to the concrete, for any tested results there are three cubic tested and the mean of these three results was listed.

Slump test was achieved for fresh concrete for the four batches (0, 20, 25, and 30%) fly ash.

The strength test was done at the age of 3, 7, 28 days and other readings between them in accordance with the ASTM C109 using cube specimen (15*15*15) cm with water/cement ratio 0.55. The specimens were cured immersed in water until the age of 28 days. The chemical analysis for the tap water shown in table (1).

Table (1): Chemical analysis of tap water used for curing concrete*

Compound	SO ₄ ⁻²	Cl ⁻¹	Ca ⁺²	Mg ⁺²	HCO ₃ ⁻²	CO ₃ ⁻²	Na ⁺¹
Concentration in ppm	81	80	128	44	122	0	50

* The analysis was carried out in the Ministry of Science and Technology labs.

The extracted concrete from curing was dried at 100 °C for 24 hr. Absorption and strength test was done for all batches.

3 Results and Discussions:

Characteristic of fly ash:

The physical properties of Portland cement and fly ash are summarized in with the chemical composition and X- ray diffraction pattern shown in table (2) and figure (3) below.

Table (2) composition of Fly Ash and Portland cement

Item	Composition	Oxides % of Portland Cement	Oxides % of Fly Ash
Iron Oxides	Fe ₂ O ₃	5	6.7
Sulfate	SO ₃	2.5	0.6
Silica	SiO ₂	26.277	34.76
Alumina	Al ₂ O ₃	4.5	16.341
Magnesia	MgO	2.02	0.437
Insoluble	-	0.36	-
CaO	-	remain	1.216
Organic	-	-	42%

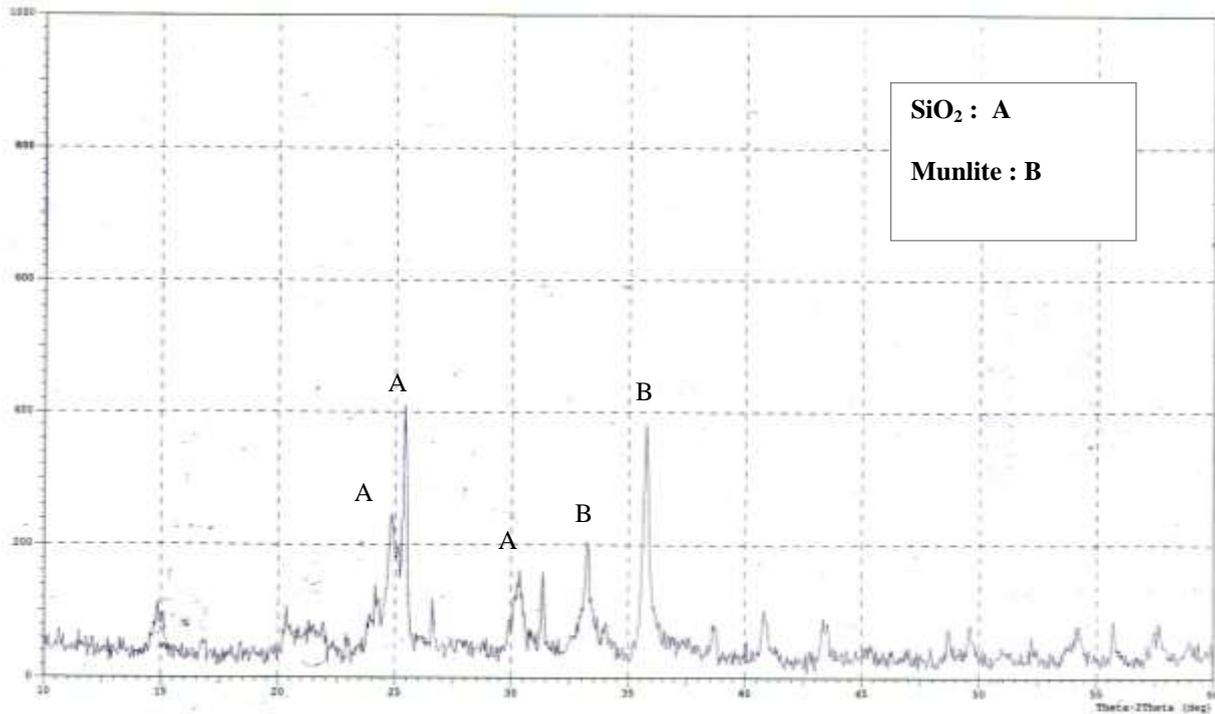


Fig.(3): X-Ray pattern of calcined fly ash

Slump Test

Slump was reduced significantly by adding fly ash, as clear from fig (4). The use of fly ash cause reduction of slump because of the fine size of its particulate which fits the pores and increase the density.

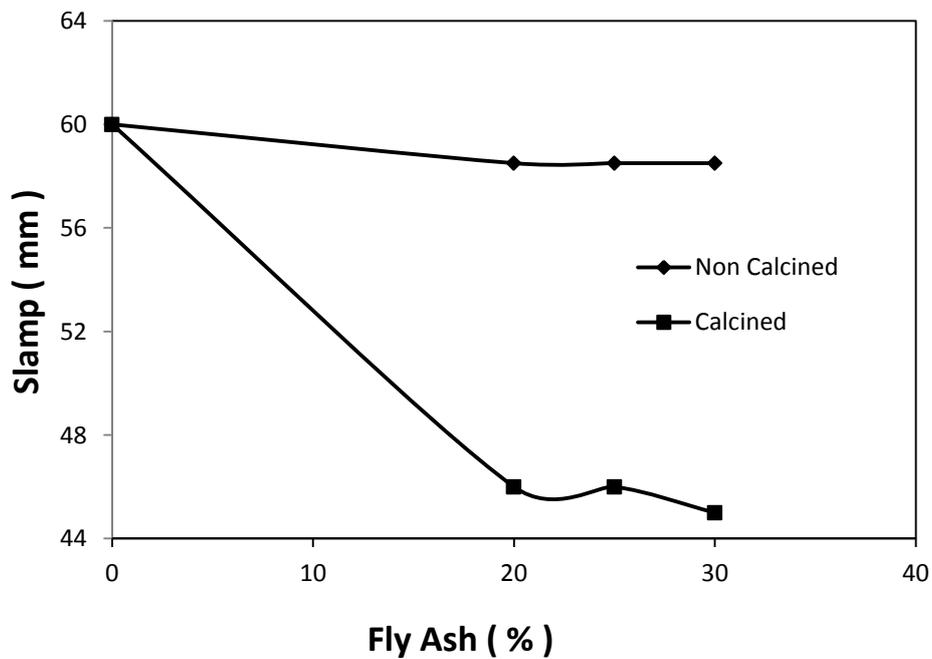


Fig.(4): The Slump of fresh concrete after adding the calcined

Absorption Test

Absorption after solidification was carried out after the recorded period, for all batches. A clear reduction in absorption for samples prepared with and without fly ash was appeared in fig (5).

The reduction in absorption due to the reduction of porosity especially in the case calcined fly ash addition.

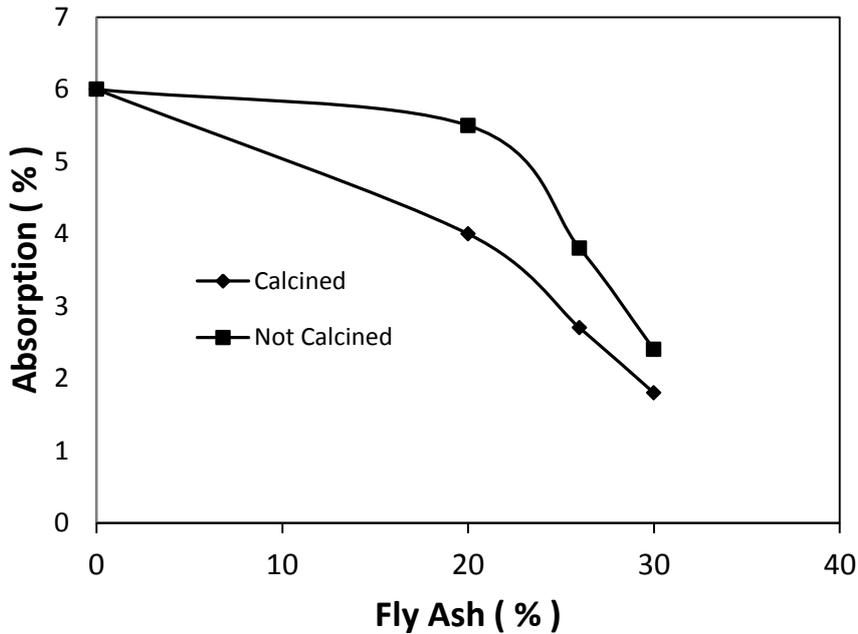


Fig.(5) Absorption ability of the concrete with addition of calcined and non calcined fly ash

Strength:

The results of the strength of Concrete are given in figures (6 and 7) with fly ash (without calcination), and with calcined fly ash in different ratios.

It can be seen that significant improvement on strength was appeared. The fine pore structure of fly ash concrete contributes to a larger resistance to the compressive attack. It has been shown that the fine fly ash decreases the pore volume of the fly ash cement paste as compared to the coarser fly ash. The calcination of fly ash reduce or remove all the organic materials which may be give a negative or nil effect on the strength of the concrete.

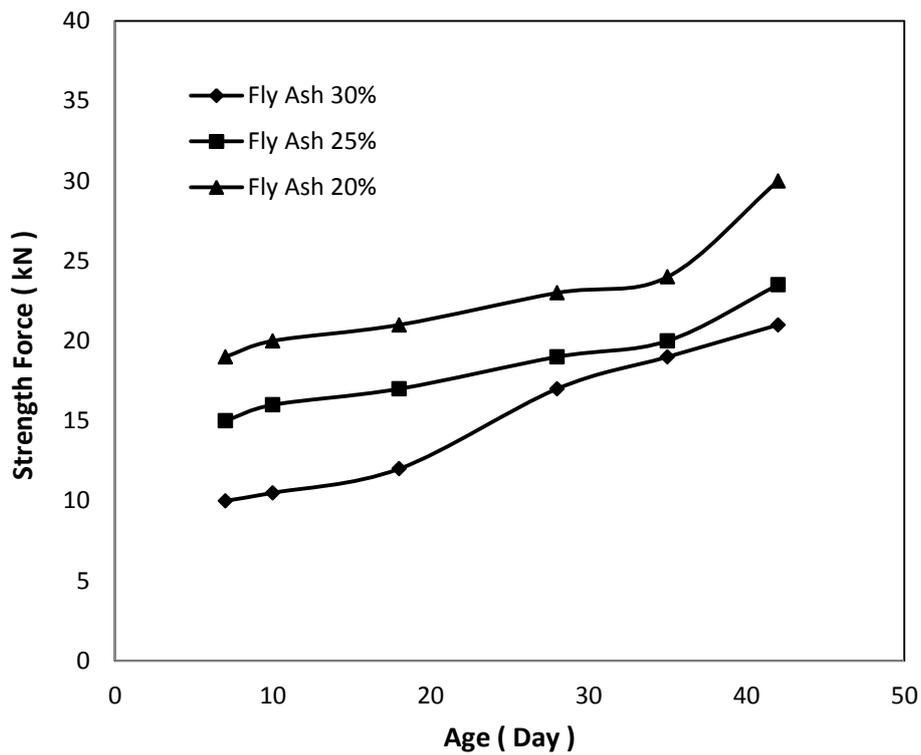


Fig.(6): The strength of concrete with aging time for fly ash addition without calcination

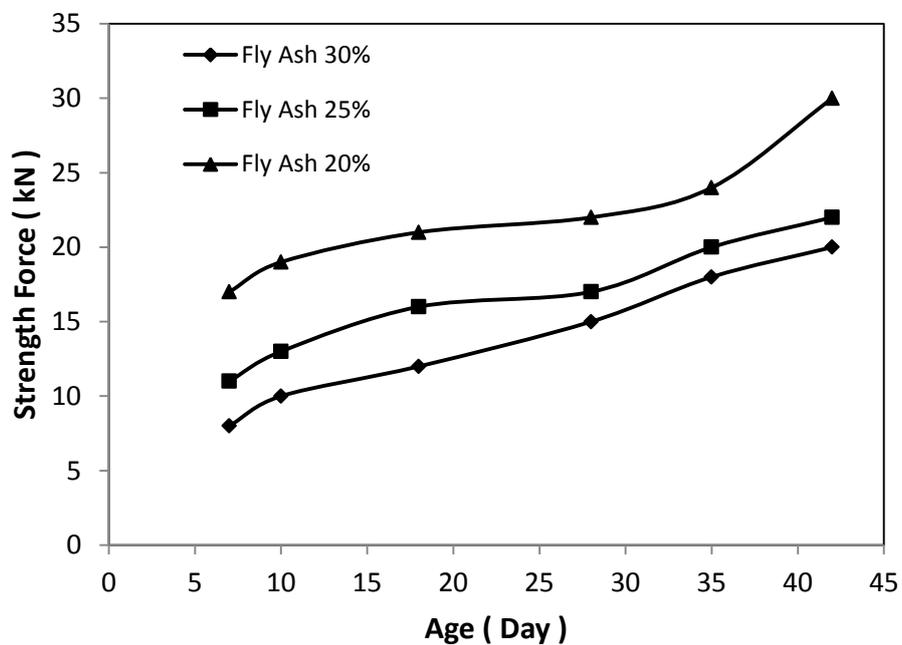


Fig.(7): The strength of concrete with aging time for calcined fly ash addition

Setting Time:

The impact of fly ash on the setting behavior of concrete is dependent not only on the composite and quantity of fly ash used, but also on the type and amount of cement.

Conclusions:

It can be concluded from the present work the following:

- 1- The calcination of fly ash remove the organic compound that decrease the objective of fly ash addition to concrete.
- 2- The slump decreases more in the case of calcined fly ash addition than in non calcined fly ash.
- 3- The water absorption decreases more in the case of calcined fly ash addition.
- 4- Strength of concrete enhanced by fly ash addition especially in the case of calcined fly ash.

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