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EXPERIMENTAL ANALYSIS OF INCORPORATION OF FLY-ASH AND SILICA FUME ON THE ENGINEERING PROPERTIES OF CONCRETE

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Abstract: - Now a day the world is witnessing the construction of very inspiring and challenging structures, the world is leaning towards the concrete jungle and the high raised concrete skyscrapers are becoming predominant structures in society. The main ingredient in the conventional concrete is Portland cement the process that are being used in the construction industry for the production of cement releases large traces of carbon dioxide which leads to rise in earth surface temperature. Many of the previous work had reported the use of fly-ash in concrete and try to use it at different ration. But using fly-ash more that 20% of cement decreases the performance of concrete. So in order to use fly-ash more than 20% without compromising the strength of the concrete, here in this work 10% silica fume was used with fly-ash in concrete. This work includes the effect of addition of fly-ash in concrete on their mechanical property. For analyzing the effect of different percentage of fly-ash it considered seven different ratios. After analyzing the effect of addition of only fly-ash in concrete, addition of only silica fume in concrete was also analyzed. for analyzing the effect of addition of silica fume in concrete three different ratio proportion was considered during experiment. It also analyzed the effect of addition of fly-ash and silica fume both in concrete. With keeping silica fume percentage constant that is 10%, fly-ash percentage gets varied and analyzes the mechanical properties of concrete. It measures the compressive and flexural properties of concrete in each case of composition. Through experiment it is found that with only fly-ash addition, the strength of the concrete get enhanced up to 20% addition of fly-ash after that it start decreasing. Whereas with 10% silica fume the mechanical strength of concrete having fly-ash get enhance up to 35% of addition. Hence through experimental result it concludes that with 10% silica fume, 35% of fly-ash can be used in concrete.

Keyword: - concrete, fly-ash,silica fume, flexural test, compression test

1. INTRODUCTION

Concrete is the most versatile man-made construction material in the world and being extensively used in all types of construction activities. The strength, durability and other characteristics of concrete be contingent upon the properties of its ingredients, the mix proportions, the technique of compaction and other controls during placing, compaction and curing. The improvements in concrete technology had flagged the way to make the finest use of locally obtainable materials by proper mix proportioning and workmanship so as to harvest a strong, durable and uniform concrete. An important part of research on concrete is the use of raw materials, cement additives, or the addition of minerals or the replacement of ingredients.

2. REVIEW OF THE WORK

1. Nawaz et.al (2020) The intention of this study was to upsurge the level of fly ash inclusion in hybrid hybrids (cement plus fly ash) using sulfate activation techniques to overcome the problem of low productivity at a young age. The levels of fly ash replacement with cement were retained at 20%, 40% and 60%. Sodium sulfate (Na2SO4) 2% by weight of the binder was used as the activator. Compact strength and flexibility tests of the samples were accomplished at 3, 28, and 90 days of age. Endurance assessments such as realization, coefficient of sadness and chloride penetration were also performed, and experimental consequences disclosed that sulfate activity increased at a young age at all levels of fly ash.
2. Zahedi et.al (2020) In this study, two different FBC fly ash from North America were employed when replacing 20% Portland cement in a concrete mix with a paving stone. The upshot of fly ash on the fresh, hard and stable properties of concrete and equivalent was appraised. It has been pragmatic that in concrete with fly ash from FBC, the desired solution of air content, air cavity structure and strength development can be achieved. In addition, FBC fly ash has enhanced concrete durability, coefficient formation and chlorite penetration resistance. Compact effect on drying is also adequate. While the high SO3 content of fly ash does not cause harmful expansion per concrete cylinder containing fast flying ash, SO3 is susceptible to sulfate attacks.
3. Fan et.al (2019)The article presents an experimental study of the mechanical properties of fly ash during heating. Tests were achieved on equipment definitely designed to study the “hot” mechanical properties of concrete. Outcomes comprise compressive strength, peak stress, young modulus, and stress ratio at ambient temperatures up to 900 ° C. Led to a smaller reduction in compressive strength and a more linear stress reply to deformation at higher temperatures due to the further reaction between reactive silica in fly ash and calcium hydride under climatic conditions.
4. Sahoo et.al (2018) This paper offerings the consequences of experiments to consider the belongings

of adding fly ash to concrete as part of the substitution of cement on compressive strength with prolonged exposure to sulfur. In addition, artificial neural networks (ANNs) were developed to predict the compressive strength of concrete at different levels of ash replacement, day hardening, water, and duration of sulfate exposure.

3. MATERIAL USED

For the experimental analysis silica fumes were used as a reinforcement element, fly ash is used in place of cement to reduce the content of cement. The different properties of silica fumes and fly-ash is shown in the below figures.

Fly-ash

It is used as a binder in concrete with cement. The chemical composition of fly-ash is mention in the below table

Fig. shows the image of fly-ash produce from power plant, (b) fly-ash used for the addition in concrete

Table Shows the chemical composition of fly-ash

Chemical contain	percentage
SiO_2	39.8
Al_2O_3	21.5
Fe_2O_3	13.7
CaO	15.2
MgO	2.8
Na_2O	1.1
K_2O	2.0
SO_3	2.4
CaO free	2.2

Silica Fume

Silica fume is a byproduct of producing silicon metal or ferrosilicon alloys. One of the most beneficial uses for silica fume is in concrete. Because of its chemical and physical properties, it is a very reactive pozzolan. Concrete containing silica fume can have very high strength and can be very durable. Silica fume is available from suppliers of concrete admixtures and, when specified, is simply added during concrete production. Silica fume consists primarily of amorphous (non-crystalline) silicon dioxide (SiO2).

The chemical composition of silica fume is mention in the below table

Table.Shows the chemical composition of silica fumes

Chemical contain	percentage
SiO_2	95.3
Al_2O_3	0.6
Fe_2O_3	0.3
CaO	0.3
MgO	0.4
Na_2O	0.3
K_2O	0.8
SO_3	0.2

In order to do compression test, 10-ton load capacity compressive machine is used which have dial gauge indicator with the help of which we data can be obtained. For flexural strength three-point bend test was conducted. The three-point bend test machine used for the experimental analysis is shown in the below fig.

Fig. shows three-point bend testing machine

Table. Properties of coarse and fine aggregate used for making concrete

Properties	Fine aggregate	Coarse aggregate
Particle size and shape	4.75 mm	20 mm
Fineness modulus	3.15	6.81
Silt content	5.58	-
Specific gravity	2.62	2.78
Bulking of sand	4.15%	-
Bulk density	1.683 g/cc	1.795 g/cc
Surface moisture	0.15	0.5%
Water absorption	1.04%	0.45%

During the preparation of sample, after filling the mould with concrete mortar little vibration was given to the mould so that it gets completely fill and remove the cavity or gas entrapped inside the concrete. The preparation of samples and giving vibration to the samples is shown in the below fig

Fig. shows the preparation of three-point bending samples

Fig. Shows the compressive samples of concrete

After preparing the samples, testing was done for concrete with different composition. In order to analyse the effect of addition of fly-ash in to the concrete, first fly-ash concrete was tested at different proportion of fly-ash.

Effect of addition of fly-ash in concrete

For analysing the effect of addition of fly-ash in concrete different percentage of fly-ash was added in to the mortar of concrete. Seven different composition of fly-ash and cement was considered during the experiment that is 10, 15, 20, 25, 30, 35 and 40 weight percentage of cement. The curing time of the concrete with different composition of fly-ash is fixed and it remain to 48 hr. so for the compression test cubic samples having 15*15*15 cm3 volume was prepared and for flexural strength sample having 150*150*700 mm3 size was prepared. The sample dimension was selected according to the IS code for compressive and flexural strength of the concrete. For getting the repeatability and accuracy of the result in each case of analysis three different samples were tested and getting the result. The reported data is the average of the three result.

For fly-ash samples the compressive testing was done and shown in the below figure

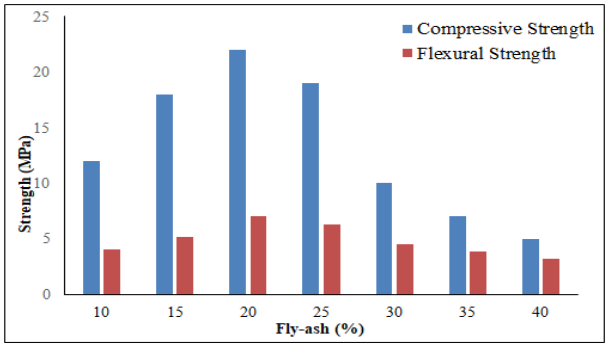

Fig. value of compressive and flexural strength of concrete having different percentage of Fly-ash

Above figure shows the value of strength of concrete at different percentage of fly-ash addition. From figure it is found that at 20% addition of fly-ash concrete is giving the best property and above 20% addition of fly-ash the property of the concrete starts decreasing. This is the main issue of not using fly-ash more than 20% in concrete. But our main objective is to increase the percentage utilization of fly-ash in concrete. for increasing the percentage of fly-ash in concrete different other cementitious constituents was also added with fly-ash in concrete. In this work silica fume was added with combine to fly-ash in concrete. But before adding combine, silica fume was added separately in to concrete and analysed the effect of addition of it at different percentage.

Effect of addition of silica fume in concrete

Silica fumes are the industrial waste and utilizing this to different application act as a waste to wealth. Silica fumes act as a fiber like structure, their aspect ratio is large. When it is added in to the concrete it acts as a reinforcement inside the concrete. Through previous work it is already known that, when fine fiber is added in to the concrete it increases the strength of the concrete. So in order to test the addition of silica fume in concrete,here in this work three different percentage of silica fumes were added in to the concrete and make the compressive and flexural samples for testing. In each case of silica fume constituents three-three samples were prepared and tested in order to maintain the accuracy of the testing. The compressive samples prepared from silica fume- concrete is shown in the below figure.

Fig.4.15Shows the compressive samples of silica fume-concrete

Compressive Strength
In order to check and to analysed the effect of addition of silica fume four different proportion of silica fume that is 10, 15, 20 and 25 weight percent of cement is used during the making of concrete. the value of compressive strength for different composition of silica fume is shown in the below table.

Table.4.8 Value of compressive strength of the silica fume-concrete

S.No.	Silica fume Percentage	Compressive strength (MPa)
1	10	20
2	15	32
3	20	25
4	25	18

From above table it is found that as the silica added in to the concrete the compressive strength of the concrete gets enhanced. It is found that, as the percentage of silica increase from 10 to 15% the strength of the concrete block increases up to 32 MPa. Whereas after increasing the percentage of silica fume the compressive strength of the concrete block start decreasing, which is mainly due to agglomeration of silica fumes inside the concrete.

Flexural Strength
Flexural test of silica fume-concrete was also tested and analysed the data. For different composition of silica fume addition in concrete the flexural strength is mention in the below table.

Table. Value of flexural strength of the silica fume-concrete

S.No.	Silica fume Percentage	flexural strength (MPa)
1	10	5.3
2	15	6.1
3	20	5.8
4	25	5.5

Above table shows the value of flexural strength at different percentage of addition of silica fumes. From table it is found that as the percentage of silica increases up to 15%, the flexural strength of the concrete gets increased. Whereas beyond 15% it starts decreasing. The comparative graph of compressive and flexural strength of concrete is shown in the below figure.

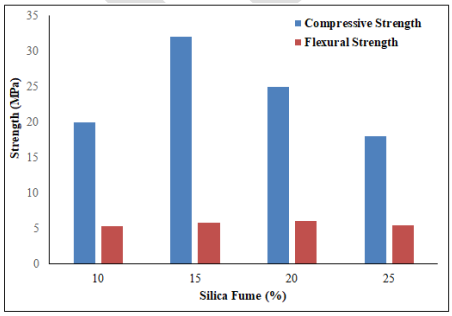

Fig shows the value of compressive and flexural strength of silica fume-concrete

Effect of silica fume and fly ash mixture in concrete
For analyzing the effect of addition of both silica fume and fly-ash, seven different compositions were considered during the experimental work. In these seven different composition, the percentage of silica fume is fixed that is 10%. Whereas the percentage of fly ash gets varied. In this work we have considered seven different proportion of fly ash that is 10, 15, 20, 25, 30, 35 and 40% and in each case the percentage of silica fume is fixed that is 10%.

Fig. compressive samples of fly ash-silica fume concrete

Fig.4.18 shows the compressive and flexural samples prepared from fly ash and silica fume mixture concrete

Compressive Strength
After preparing the samples compressive strength of the mixture concrete samples were tested and for each case of composition three-three samples were tested. The value of compressive strength for silica fume-fly ash mixture concrete at different composition is mention in the below table

Table.4.10Shows the value of compressive strength of the silica fume-fly ash mixture concrete

S.No.	Silica fume Percentage	Fly-ash percentage	Compressive Strength (MPa)
1	10	10	18
2	10	15	21
3	10	20	23
4	10	25	28
5	10	30	32
6	10	35	35
7	10	40	33

Above table shows the value of compressive strength of silica fume and fly ash mixture concrete. from table it is found that as the percentage of fly ash increases with 10% of silica fume the strength of the concrete gets increases up to 35% of addition. Whereas beyond that the strength of the concrete get decreases.

Flexural Strength
Three-point bend test was also performed to measure the flexural strength of the silica-fly ash concrete flock. The samples were prepared and tested for each set of proportion. The value of flexural strength for different composition of

the concrete is mention in the below table.

Table. Value of flexural strength of silica fume-fly-ash mixture beam at different composition

S.No.	Silica fume Percentage	Fly-ash percentage	Flexural Strength (MPa)
1	10	10	4.8
2	10	15	5.4
3	10	20	7.8
4	10	25	8.3
5	10	30	8.7
6	10	35	9.1
7	10	40	8.5

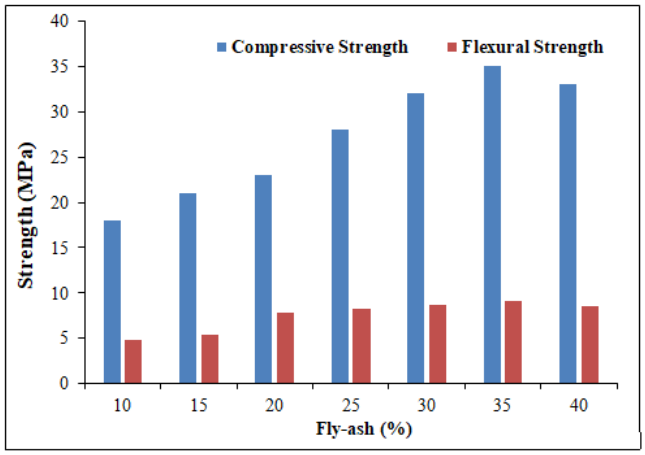

Fig.value of flexural and compressive strength of the fly-ash silica mixture concrete

From above figure it is found that with increase in percentage of fly-ash with 10% silica the compressive and flexural strength of the concrete get increases, whereas beyond 35% the properties start decreasing.

CONCLUSION

- With the addition of fly-ash the compressive and flexural strength of the concrete get enhance up to 20% addition, whereas after that the strength of the concrete start decreasing.
- Due to this, there is a limitation of using fly-ash up to certain percentage of cement that is not more than 20%.
- Silica fumes act as a fiber reinforcement and increases the strength of the concrete.
- With increase in percentage of silica fumes the strength of the concrete increases, but after certain percentage the agglomeration of silica fumes decreases the strength of concrete.
- Due to non-uniform distribution of silica fume and agglomeration, it becomes more prone to the crack formation during loading which ultimately decreases the strength of the concrete.
- With the addition of fly-ash in combination with silica fumes, it is found that the compressive and flexural strength of the concrete get increases up to 35% addition of fly-ash.
- With only 10% addition of silica fume, fly-ash can be used up to 35 weight percentage of cement which ultimately save the lot of manufacturing amount.
- Large amount of use of fly-ash also increases the waste to wealth policy of government and also reduces the pollution created due to fly-ash production

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