PARTIAL REPLACEMENT OF CEMENT WITH FAL- G AND SILICA FUME

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Abstract **- Silica Fume (SF) is cementitious material which gives High Strength in concrete. It is used for production of high performance concrete. It also reduces the water demand in concrete because of its high surface area. FAL–G reaction creates a lesser amount of greenhouse gas and it does not depend upon external heat. It is eco friendly binding material as compares to ordinary Portland cement. A suitable concrete mix of M50 grade was made with different quantity of cement, Fly Ash, lime, Gypsum , fine aggregate, coarse aggregate, silica fume, and water and chemical admixture. In this design mix, we partially replace silica fume and FAL-G with cement with 0- 30% removal of cement.**

The micro silica with FAL-G concrete mix gives ultra high strength after 28 days testing. FAL-G has been used as cement replacement material for (0%, 10%, 20%, and 30%) cement replacement levels with different values of silica fume (0%, 10%, 20%, and 30%) by weight of cement. The test specimens were cast using cement, fine aggregate, coarse aggregate, fly ash, silica fume, super plasticizer, water, Lime and Gypsum. Admixture is used in concrete to minimize the water cement Ratio without affect the workability and strength of concrete .Three specimens were tested for 7, and 28 days with each proportion of silica fume and FAL-G replacement total 24 cubes and 24 cylinders were cast and these specimens were tested in compression testing machine.

Key Words: **Compressive Strength, split tensile strength, FAL-G, silica fume and high strength concrete.**

1. INTRODUCTION:

FAL-G is the advanced pozzolanic binder. In the presence of water FAL-G gives strength like other hydraulic materials. FAL-G is the cementitious mixture consists of Fly ash (FA), Lime (L) and Gypsum (G). It is low-cost and environmental-friendly material very useful in construction industry. FAL–G reaction creates a lesser amount of greenhouse gas and it does not depend upon external heat. All these materials are available in form of wastes and by-products from industries and are available in large quantities in the construct areas. It is eco friendly binding material as compares to ordinary Portland cement. We know that Gypsum and Fly ash are industrial by-products and quantity of Lime and gypsum are depending upon the property of fly ash. Cement usage can be minimizing by using the FAL-G as a cementing material without any change in strength and durability. The early strength of FAL-G can be achieved by regulating the water cement ratio by the use of super plasticizers .FAL-G is economically and environmentally safe.

Silica fume is by-product pozzolanic material. It is very reactive pozzolanic material. Its average particle diameter is about 150nm. Silica fume is used for production of high performance concrete. It is also known as micro silica. Silica fume is mineral composed of submicron of silicon dioxide. Silica fume is 150 times finer than cement. It has ultra micro structure so it is used for gap filling. By using FAL-G air pollution reduce by avoiding the use of fossil fuel. Motive of using FAL-G as building material is as follows:-

- To enhance the use of fly ash which is industrial by-product, as an ingredient of building material. The pollution reduced by utilizing the waste ash.
- FAL–G reaction creates a lesser amount of greenhouse gas and it does not depend upon external heat.
- It is eco friendly binding material as compares to cement.

2. MATERIALS AND EXPERIMENTAL METHODOLOGY:

2.1 Cement:

Ordinary Portland cement 53 grades with physical and chemical properties as given in table 3 have been used in this experimental study. The specific gravity of cement is 3.15. Cement used in construction work should be inorganic. Cement is partially replaced with fly ash and silica fume for high strength concrete. . When cement is used with water its chemical constituents reacts with each other. This chemical reaction is called hydration. Cement setting time depends upon the materials which are used with cement in concrete. Cement production is the one of the biggest industries in the world. Emission of CO_2 into the air is increased day by day. Blanket that surrounds the planet is damages due to CO_2 emission.

2.2 Fine aggregates:

Locally available river sand confirming to grading Zone II was used in this experimental work. Specific gravity and other properties of fine aggregates like specific gravity and fineness modulus, moisture content are given in Table 1. Fine aggregates are very important for increase the strength of concrete. Fine aggregate provide dimensional stability. When the aggregates are sieve through 4.75 mm sieve, the aggregates passed through this sieve is called as fine aggregates. Fine aggregates are very important for increase the strength of concrete. Fine aggregate provide dimensional stability. When the aggregates are sieve through 4.75 mm sieve, the aggregates passed through this sieve is called as fine aggregates.

Table 1:- Properties of Fine aggregates

Fineness modulus	2.96
Specific Gravity	2.65
Grading zone	Zone II
Moisture content	1.521

2.3 Coarse Aggregate:

Coarse aggregate are those, retained on the No. 4 (4.75 mm) sieve. Specific gravity of coarse aggregates is given in Table 2. The sieve analysis of coarse aggregate was done. Combination of two different aggregate 20mm & 10mm in the proportion 60% & 40% was used. These aggregate mixed together as per grading requirements to make graded aggregate. Normally 20mm aggregates are used in design mix in this project 10mm and 20mm size aggregate are used for high performance concrete. Coarse aggregates are larger in size as compare to fine aggregates. In concrete coarse aggregate is responsible for durability of concrete.

Table 2:- Properties of coarse aggregates

Shape	Angular
Maximum Size	20 mm
Specific Gravity	2.74
Grading ratio of 10mm to 20mm aggregate	1:1.5

2.4 Fly Ash:

Fly ash is a byproduct of the thermal power plants. Fly ash normally produced from burning anthracite or bituminous coal.

Class F fly ash was used have a lower content of Cao and exhibit Pozzolanic properties. Specific gravity of fly ash is 2.13. Physical and chemical properties of fly ash are given in table 3. Fly ash is a Pozzolanic material, which provides high concrete strength than the Portland cement. Modulus of elasticity is observed to be low at early ages and high at later ages for concretes incorporated with fly ash.
The effects of fly ash on creep of concrete are influenced to the extent of content of fly ash that influences the strength of concrete. Fly Ash particle are very small in size about 95% of the particles having size less than 1um.The ball bearing effect offered by spheroids of fly ash keeping all the constituents of concrete in mobility.

Figure -1: Fly Ash

2.5 Silica Fume:

The specific gravity of silica fume is 2.2. It consists of 0.1 to 1 micron sized fine, smooth spherical glassy particles with fineness of 20m²/gm. Its average diameter is about 150nm. Physical and chemical properties of fly ash are given in table 3. Silica fume enhance the strength and pump ability of concrete. It also reduces the water demand in concrete because of its high surface area. Lime present in concrete is very dangerous compound because it reacts with other chemical compounds present in concrete and causing expansion so silica fume is used with lime to avoid expansion.
Silica fume particle are very small in size about 95% of the particles having size less than 1um. Silica fume have large surface area because its particles are too small because of its larger surface area water demand in concrete is increase. Silica fume have high crack resistance and it have self waterproofing property. Because of this it is used for mixing. Silica fume enhance the strength and pump ability of concrete

Figure -2: Silica fume

Table -3: Physical and chemical properties of materials.

Property	Portland cement	Fly Ash	Silica fume
SiO2 (%)	20.78%	Min 35	90-96 %
Al203 (%)	4.44%	25-29%	0.5-0.8%
Fe2O3 (%)	2.88%	4.5-4.8%	0.2-0.8%
Cao (%)	63.78%	0.5-1.2%	0.1-0.5%
MgO (%)	3.66%	0.3-0.5%	0.5-1.5%
Specific gravity	3.15	2.13	2.2
Physical form	Powder form	Powder form	Powder form

2.6 Lime:

Lime is known for very slow setting and progressive strength gain over ages. The value of lime depends upon the properties and types of fly ash in concrete. Lime is a cementitious material known for very slow setting and increase strength. These materials are used widely in different constructions. In case of short supply cement can be used as source of lime gives the same quantity of bricks and blocks.

2.7 Gypsum:

Gypsum plays an very important role in controlling the rate of hardening of cement gypsum is added in concrete to control the setting time of cement if not added cement will set immediately after mixing .Gypsum is used for production of high performance . To overcome the slow strength gain at early ages by using cement route is not the good way to produce the strength of FAL-G in all aspect.

2.8 Water:

The amount and quality of water effects fresh and hardened properties of concrete which includes workability, compressive strength, tensile strength, flexural strength, durability, permeability drying shrinkage

and potential for cracking because of this controlling the amount of water is important. The water which is used in concrete for mixing should be free from organic matter, dust, oil, salt, sugar, alkali acid and vegetable growth. Water cement Ratio is defined as weight of cement to the weight of water in given concrete mixture.
Water cement Ratio falls under 0.4 to 0.6 as per IS Code 10262 (2009).

Water cement Ratio affects the strength of concrete. In concrete mix we have to calculate water cement Ratio very carefully because too much water can decrease strength and durability of concrete.

2.9 Super plasticizer:

Super plasticizer is used in concrete to minimize the water cement Ratio without affect the compressive strength of concrete and workability of concrete .The addition of admixture generally improve the performance of concrete. It makes the concrete self consolidated and high performance concrete. Strength of concrete is increase when water cement Ratio is decrease. Super plasticizer is also known as water reducer.

3.0 EXPERIMENTAL PROCEDURE:

A suitable concrete mix of M50 grade was prepared with different quantities of cement, Fly Ash, lime, Gypsum , fine aggregate, coarse aggregate, silica fume, water and chemical admixture. In this design mix, we partially replace silica fume and FAL-G with cement with 0- 30% removal of cement.
The micro silica with FAL-G concrete mix gives ultra high strength after 28 days testing. FAL-G has been used as cement replacement material for (0%, 10%, 20%, and 30%) cement replacement levels with different values of silica fume (0%, 10%, 20%, and 30%) by weight of cement. The test specimens were cast using cement, fine aggregate, coarse aggregate, fly ash, silica fume, super plasticizer, water, Lime and Gypsum. Admixture is used in concrete to reduce the water cement Ratio without affect the workability and strength of concrete .Three specimens were tested for 7, and 28 days with each proportion of silica fume and FAL-G replacement total 24 cubes and 24 cylinders were cast and these specimens were tested in compression testing machine.

Figure -3: Tested concrete cubes

Table -4: Details of Mix Proportions of Concrete

S.No.	Mix description	cement	Aggregates		Cement replacement	
			fine	coarse	FAL-G	Silica fume
1	0%	1680	4040	2095	0	0
2	10%SF+ 10%FAL-G	1344	4040	2095	168	168
3	20%SF+ 20%FAL-G	1008	4040	2095	336	336
4	30%SF+ 30%FAL-G	672	4040	2095	504	504

M50 Grade of concrete is prepared as per IS 10262: 2009 in which w/c Ratio is 0.35 and mix proportion in Ratio 1:1.2:2.4 (cement: fine aggregates: coarse aggregates).In the mixes there is a replacement of cement with FAL-G and micro silica.
To study the effect of FAL-G and silica fume in the compressive strength characteristic of high performance concrete specimens were cast. FAL-G has been used as cement replacement material for (0%, 10%, 20%, and 30%) cement replacement levels with different values of silica fume (0%, 10%, 20%, and 30%) by weight of cement. From design mix proportions (refer Table 4) it is concluded that total 24 cubes and 24 cylinders will be casted .FAL-G has been used as cement replacement in which percentage of Fly ash is (0%, 6.5%, 13%, 20%) Percentage of Lime is (0%, 1%, 2%, and 3%) and percentage of Gypsum is (0%, 2.5%, 5%, and 7%).Percentage used for super plasticizer is 0.4% of weight of cement. Replacement of Portland cement with 30% of Silica fume and 30% of FAL-G gives high tensile strength.

Table -5: Compressive strength of cubes on 7 and 28 Days

S No.	FAL-G	Silica fume	Compressive strength (N/mm^2)	
			7 days	28 days
MIX 1	0%	0%	35.1	53.3
MIX 2	10%	10%	36.4	54.5
MIX 3	20%	20%	35.9	56.3
MIX 4	30%	30%	38.1	61.0

It has been clearly shown by the above mentioned results that concrete achieved higher strength at 60% replacement of cement after 7 days as shown in chart 1.
There is no effect of activated blend effect of fly ash and micro silica for good M50 grade concrete. The compressive strength [61.06N/mm2] is the optimum value at 60% replacement of cement [30% FAL-G + 30% Micro silica]. Tensile strength of concrete is also increased with the use of both Silica fume and fly ash in the cement concrete. Replacement of Portland cement with 30% of Silica fume and FAL-G gives high compressive strength. The specimen used for tests was of 150 x 150 x 150 mm size cubes and 150 mm x 300 mm cylinders.

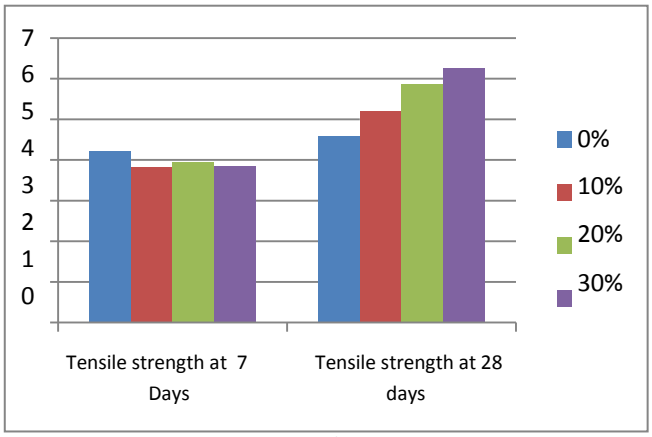

Chart -1: Compressive strength of cubes on 7 and 28 Days

Table -6: Split Tensile Strength of cylinders on 7 and 28 Days

S No.	FAL-G	Silica fume	Tensile strength (N/mm^2)	
			7 days	28 days
MIX 1	0%	0%	4.22	4.58
MIX 2	10%	10%	3.81	5.19
MIX 3	20%	20%	3.94	5.87
MIX 4	30%	30%	3.86	6.25

After casting, the specimens (cylinder) were tested by compression testing machine at 7 day and 28 days for split tensile strength shown in Table 6 and also see chart 2.Tensile strength of concrete is also increased with the use of both Silica fume and fly ash in the cement concrete. The 150x150mm cube mould is used for casting, after casting all the test cubes are finished with a trowel. All the cubes and cylinders are stored at temperature of about 29o C. They are dismantled after 24 hours, and water sprinkling is done 2 times in 24 hours.

Figure -4: Split Tensile Strength of cylinder

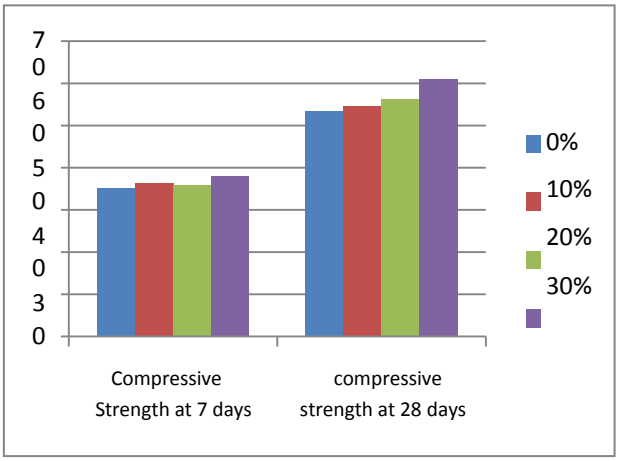

Chart -2: Tensile strength of cubes on 7 and 28 Days

It concluded that concrete achieved higher tensile strength at 60% replacement of cement after 7 days as shown in chart 2. The tensile strength [6.25N/mm2] is the optimum value at 60% replacement of cement [30% FAL-G + 30% Micro silica]. FAL-G concrete by the use of Silica fumes which acts as a strength accelerator and set accelerator along with super plasticizer. In this, the input of gypsum should be up to threshold limit that can enhance or accelerate properly with the sulpho aluminates hydrates. Research on FAL-G and silica fume has concluded better performance characteristics such as high strength, durability, excellent resistance against chloride attack, low environmental impact compare to Portland cement. By using FAL-G air pollution reduce by avoiding the use of fossil fuel. Absence of burning and heavy compaction during manufacturing of FAL-G bricks saves energy, cost and makes it environment friendly hence this technology could be implemented to replace clay bricks. In this study, compressive strength and tensile strength was measured as per recommendation of IS code.

4.0 RESULTS AND DISCUSSION:

- It has been clearly shown by the above mentioned results that concrete achieved higher compressive strength at 60% replacement of cement after 7 days. There is no effect of activated blend effect of fly ash and micro silica for good M50 grade concrete.
- The compressive strength [61.06N/mm^2] is the optimum value at 60% replacement of cement [30% FAL-G + 30% Micro silica].
- It concluded that concrete achieved higher tensile strength at 60% replacement of cement after 28 days. The tensile strength [6.25N/mm2] is the optimum value at 60% replacement of cement [30% FAL-G + 30% Micro silica].

5.0 CONCLUSIONS:

- The compressive strength of blend effect of FAL-G and micro silica concrete is comparatively greater than that of control mix.

- The micro silica with FAL-G concrete mix gives ultra high strength after 28 days testing.
- It is calculated that partial replacement of Cement with Silica Fume along with FAL-G material makes the project Cost effective.
- Tensile strength of concrete is also increased with the use of both Silica fume and fly ash in the cement concrete. Replacement of Portland cement with 30% of Silica fume and FAL-G gives high tensile strength. The maximum increase in compressive strength is observed at 30% replacement of silica fume and FAL-G.
- Silica fume mix provides strength with time. We had find that FAL-G mix did not provide initial strength it gain strength with time. But FAL-G in addition with Micro silica is quite durable than OPC. As the lifetime is specified for cement but it is quite difficult to specify the lifetime of the FAL-G.
- Alkali activation of fly ash is most considerable criteria from improving the pozzolanic properties of fly ash.
- FAL-G and Silica Fume could be used as an alternate building material. As the final setting time of the Silica fume concrete is quite lesser than the normal Portland cement concrete due the presence of Super plasticizer. So, this can also be used for increasing the construction speed.
- FAL-G composition and Micro-silica are the by-products of industrial waste which can be used in concrete technology and makes the buildings/ structures environment friendly.

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