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Original Article

A Characteristic Study of Concrete Strength and Durability with Fly Ash and Silica Fumes

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Abstract *- Concrete plays an indispensable part during construction. Presently, while planning a design, the most significant is the strength and durability of concrete. An experimental investigation has been taken up to concentrate on the strength and toughness of properties of concrete with and without admixtures. the experimental outcomes show that the concrete containing mineral admixtures has better protection from resistance to chemical attack and improves durability execution. Unusual construction needs various properties that must be fulfilled by concrete for high performance. Mineral admixtures, for example, fly ash and silica fume, are in effect widely utilized in concrete for reasons of strength, durability, and economy.*

Keywords *- Acid Attack, Chemical Attack, Fly Ash, Durability, Silica Fume.*

1. Introduction

Cement and concrete are enormously flexible materials, which can be used in nearly all engineering projects, whether creating new communities (or) enhancing accessible infrastructure. Owing to the advancements in concrete technology, Mineral admixtures such as fly ash (FA) and silica fumes are being extensively used in concrete for reasons of strength, durability and economy.

Mineral admixtures such as fly ash and condensed silica fume can be mixed to generate high-performance concrete. High-performance concrete (HPC) is a block of concrete made with suitable materials carefully mixed, transported, placed, and cured so that the resultant concrete gives an excellent performance, such as high strength, ease of placement and compaction without segregation, enhancement of long-term mechanical properties, toughness, and long life in adverse environmental conditions in the structure in which it is used in the environment to which it is likely exposed.

2. Materials Used for HPC

It is necessary to get the most out of all of the materials used in the production of high-strength concrete.

2.1. Cement

Cement is one of the components used in high-strength concrete. When selecting Portland cement for use in high-strength concrete, the fineness and chemistry of the cement must be carefully considered. Tricalcium aluminates (C3A), Tricalcium silicate (C3S), and Dicalcium silicates make up the cement (C2S). Cement with a higher C3A content has better strength. However, because high C3A content in cement causes quick flow loss in fresh concrete, it should be avoided in HPC. to avoid alkali-silica reactivity, low alkali cement was employed.

2.2. Fly Ash

Fly ash is a finely divided residue produced by the combustion of powdered coal, which is carried by the fuel gases and collected using an electrostatic precipitator. Fly ash is generally pozzolanic and self-cementing due to its mineralogical makeup, tiny particle size, and amorphous character. the use of fly ash as a partial replacement for cement can result in significant cost savings, as well as other benefits such as improved workability, reduced bleeding and heat of hydration, increased ultimate strength, impermeability, chemical durability, and improved resistance to thermal cracking energy consumed in the final product manufacturing.

A pozzolana is defined as "a siliceous or siliceous and aluminous material that, when finely divided form and in the presence of moisture, chemically reacts with calcium hydroxide at ordinary temperature to form compounds possessing cementitious properties." However, most fly ash will yield a strength of 70 MPa. the typical chemical composition of fly ash is shown in the given table 1 below.

Table 1. Chemical Composition of Fly Ash

SiO2	61.4
Al2O3	25.5
Fe2O3	4.2
CaO	1.44
MgO	1.08
Fineness (m^3/Kg.)	600
Specific gravity	2.19

2.3. Silica Fume

In the manufacturing of silicon or ferrosilicon alloy, silica fume is produced by reducing high-quality quartz with coal in an electric arc furnace. Another substance that is utilised as an artificial pozzolanic admixture is micro silica, also known as condensed silica fume. Silica fume, often known as micro silica, is a relatively novel substance with the following properties.

1. Micro silica is first made as an unidentified ultra lime powder.
2. Sio2 content of at least 85%.
3. Particles with a mean size of 0.1 to 0.2 microns.
4. A particular surface area of 15000 kg/m2 is required.
5. Particles have a spherical form.

Table 2. Silica fume size

Sio_2	90.7
Al_2O_3	0.68
Fe_2O_3	2.2
Cao	0.5
Mgo	1.47
Fineness (m^3/kg)20000	20000
specific gravity	2.3

Fresh concrete that contains silica fume is more cohesive and less likely to segregate than concrete that does not include silica fume. the bleeding in concrete containing silica fume is significantly decreased. the unit weight of concrete does not vary considerably when silica fume is used. It increases the durability of concrete by lowering the permeability of the pore structure, which minimises the transport of damaging ions, and by lowering the calcium hydroxide concentration, which increases resistance to sulphate attack. the potential of silica fume concrete to shield embedded steel from corrosion will improve as its durability improves.

2.4. Fine Aggregate

It should contain a large number of fine particles, and hence the use of coarse sand is preferable. It should be free from impurities, chloride and alkali reactivity. It should give the minimum voids ratio and be free from deleterious material such as clay, silt content and chloride contamination.

2.5. Coarse Aggregate

Crushing strength, durability, elasticity modules, maximum size, gradation, form, surface texture character, the proportion of toxic particles, flakiness, and elongation indices are all attributes that should be present in aggregate.

The aggregate's specific gravity is used to determine its quality. A low specific gravity might indicate a high level of porosity and, as a result, poor durability and strength. the specific gravity of the aggregates is quite essential. the specific gravity will have a significant impact on the concrete density. the specific gravity of aggregate typically ranges between 2.4 and 2.90. the coarse aggregate should be devoid of harmful elements and in good condition.

2.6. Water

Water is an important ingredient of concrete as it actively participates in the chemical reactions with cement. Since it helps to form the strength-giving cement gel. the quantity and quality of water are required to be looked into very carefully. Since the water affects the strength, it is necessary for us to go into the purity and quality of water.

It is generally stated that the water fit for drinking is fit for making concrete portable drinking water is normally used for mixing and curing whose PH value is around 7.

3. Scope and Objectives

3.1. Scope

The scope of this project is to study the strength and durability of HPC by using mineral admixtures fly ash and silica fumes. Different concrete mixes with and without mineral admixtures [fly ash & silica fumes] have been tested for their compressive strength. the concrete cubes caste with & without mineral admixtures is subjected to various durability tests. From the test results, the optimum mix proportions, which satisfy both high strength and high durability, could be arrived at.

3.2. Objectives

The main objectives are

- ✓ The effective utilization of industrial waste products such as fly ash silica fume in concrete technology reduces environmental pollution.
- ✓ To design a concrete mix to give a high strength concrete by using mineral admixtures.
- ✓ To test the specimen for their strength property and durability
- ✓ To compare the result for obtaining the effect of mineral admixtures in normal concrete.

4. Investigation on Strength of the Concrete

A study is made on the strength and durability of concrete by using mineral admixtures fly ash and silica fumes. the experiment is conducted on caste cubes, which are prepared by the replacement of cement with fly ash silica fumes. This chapter deals with the mixed design preparation of the specimen, casting and testing the specimen. the test has been conducted to compare the strength of HPC and study their durability.

4.1. Casting of Test Specimen

The standard size cube specimen was to determine the strength of the concrete (HPC). the test specimens are of the

size 150mm*150mm*150mm. the various ingredients are mixed in the specified proportions as shown in the table-3 and filled in the moulds of the specimens. the specimens are compacted by using the table vibrator. After 24 hours, the specimens are demoulded and kept immersed in water for curing.

4.2. Test Procedure

The specimen dumped in water was taken just before the testing was done. the dimension and weights of the specimens are to be taken. the specimen is placed in the 300tonnes compression testing machine. the specimen is to be placed in the machine in such a manner that the load is to be applied to the opposite side of the cubes as cast, that is not at the top and bottom, the axis of the specimen is to be carefully aligned with the centre of the thrust of the spherically seated platen no packing is to be used between two faces of the specimen and the steel platens of the testing machine. the load is to be applied gradually until the specimen breaks down. the maximum load applied to the specimen is to be recorded, and the appearance of the cracks and any unusual features in the types of failure is noted.

5. Experimental Investigation on Durability

The compressive strength of the concrete is increased by the use of mineral admixtures such as fly ash silica fume. Fly ash, when used in concrete, contributes to the strength of the concrete due to its pozzolanic reactivity.

The replacement of cement with silica fume can increase the strength remarkably. Silica fume and calcium hydroxide around the aggregates improves the bond between the aggregates and the cement matrix.

Fig. 1 Before Application of Load

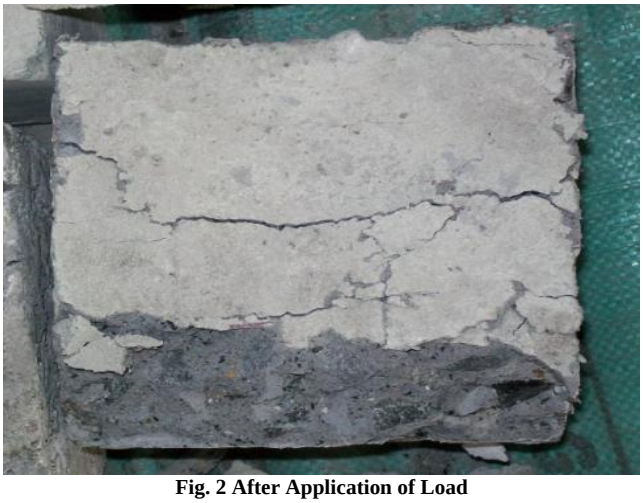
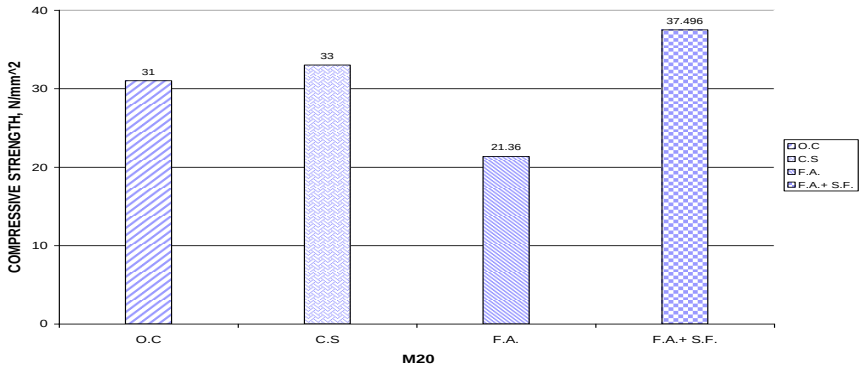


Fig. 2 After Application of Load

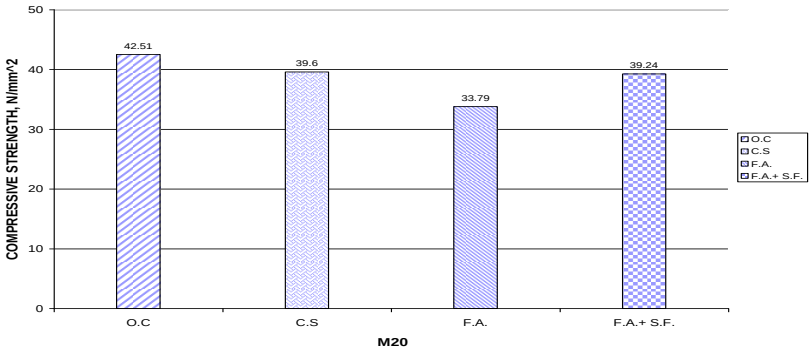
Table 3. Test Results

S.No	Grade of Concrete	Mix identification	% of fly ash in cement	% of micro silica fume	7th-day strength	28th-day strength
1	M_{20}	M_{12}	20%	10%	37.496N/mm^2	39.24N/mm^2
2	M_{20}	M_3	-	-	31N/mm^2	42.51N/mm^2



Cube Compressive Strength (7 Days)

Fig. 3 Variation of M_{20} grade concrete compressive strength at 7 days.



Cube Compressive Strength (28 Days)

Fig. 4 Variation of M_{20} grade concrete compressive strength at 28 days

5.1. Durability

The capacity of cement concrete to withstand weathering, chemical assault, abrasion, and other degradation processes is characterised by its durability. One of the most significant advantages of employing fly ash concrete is that it improves the long-term durability of concrete structures, owing to its decreased permeability and enhanced microstructure.

Using fly ash concrete improves the following important qualities.

1) The action of the pozzolanic.
2) Pore size retention
3) Improvements to the microstructure of concrete.
4) Concrete permeability is reduced.
5) The ability to withstand chemical attacks.

5.2. Significance of Durability

When designing a concrete mix (or) designing a concrete structure, the exposure condition at which the concrete is supposed to withstand is to be assessed at the beginning with good judgment. in the case of foundation, the soil characteristics are also required to be investigated. It is reported that in industrially developed countries, over 40% of the total resources of the buildings industries are spent on repairs and maintenances. in India, the money that is spent on the repair of the building is also considerable.

5.3. Impact of W/C Ratio on Durability

For durable concrete, the use of the lowest possible w/c ratio is the fundamental requirement to produce dense and impermeable concrete.

5.4. Permeability

W/c ratio is the fundamental point for concrete durability. Another important point for consideration is the permeability of concrete. When we talk about the durability of concrete, generally, we start discussion from the permeability of concrete as it has as much wider and more direct repercussion on durability than that of w/c ratio. for example, micro-cracks at transition zone are a consideration for permeability, whereas the w/c ratio may not be involved directly. It may be mentioned that micro-cracks in the initial stage are so small that they may not increase the permeability.

6. Acid Attack

Acid is not completely resistant to concrete. Depending on the kind and quantity of acid, most acid solutions will degrade Portland cement either slowly or quickly. Certain acids, such as oxalic and phosphoric acids, are completely safe to consume. Concrete is vulnerable to liquids with a PH of less than 6.5. Only when the PH falls below 5.5 does the attack become serious. A PH value of less than 4.5 indicates a serious attack. Corrosion can occur if acids or salt solutions access the reinforcing steel through fractures or porosity in the concrete, causing cracking.

6.1. Acid Test

Then concrete cubes specimens are immersed in this solution. After 14 days of curing, the specimen is subjected to a visual observation about the deterioration of concrete cubes, and also we find out the water absorption test and strength test. the chemical solution of H_2So_4 is prepared with 3% H_2So_4 diluted in water.

6.2. Chloride Attack

Chloride attack is one of the most important aspects of consideration when we deal with the durability of concrete, and chlorite attack is particularly important because it primarily causes corrosion of reinforcement statistics have indicated that over 40% of failure of structures is due to corrosion of reinforcement.

6.3. Chloride Test

The concrete cube specimens are immersed in NaCl solution (3.5%).After14 days of curing, the specimen is subjected to a visual observation about the deterioration of concrete cubes, and also we find out the water absorption test and strength test.

Table 4. Results of Water Absorption Test

s.no.	Identification of Specimen	Dry weight of before the acid attack(kg)	Saturated weight of after the acid attack(kg)	Percentage of weight loss (%)	Visual observation
1.	M_3	8.4	7.95	5.36	the surface of the concrete cube has deteriorated &coarse aggregate is seen.
2.	M_{12}	8.48	8.4	1	

Table 5. Results Of Compressive Strength Of Specimens

S.No	Identification of specimen	Specimen no	Original compressive Strength of cube (N/ mm^2)	Compressive Strength of cube after the acid attack. (N/ mm^2)
1	M3	1	34.44	30.52
2	M12	2	30.08	28.34

Fig. 5 Before the Acid Attack

Fig. 6 After the Acid Attack

Table 6. Results of Water Absorption Test

S.No.	Identification of Specimen	Dry weight of before the chloride attack(kg)	Saturated weight of after the chloride attack(kg)	Percentage of weight loss (%)	Visual observation
1.	M_3	8.7	8.7	No change in weight.	No deterioration is observed.
2.	M_{12}	8.4	8.4		

Table 7. Results of Compressive Strength of Specimens

S.No	Identification of specimen	Specimen no	Original compressive Strength of cube (N/ mm^2)	Compressive Strength of cube after the chloride attack. (N/ mm^2)
1	M3	1	24.416	26.416
2	M12	2	41.42	43.410

6.4. Sulphate Attack

Solid sulphates do not attack the concrete severely, but when the chemicals are in solution, they find entry into porous concrete and react with the hydrated cement products of all the Sulphate; magnesium Sulphate causes maximum damage to concrete. A characteristics whitish appearance is the indication of sulphate attack.

6.5. Sulphate Test

The chemical solution is prepared with $MgSo_4$ and $NaSo_4$ in the ratio of 1:1 to make a 3% salt solution. Then concrete cubes specimens are immersed in this solution.After14 days of curing, the specimen is subjected to visual observation about the deterioration of concrete cubes, and also we find out the water absorption test and strength test.

Table 8. Results of Water Absorption Test

S.No.	Identification of specimen	Dry weight before sulphate attack (kg)	Saturated weight after sulphate attack (kg)	Percentage of weight increased (%)	Visual observation
1.	M_3	8.520	8.7	2.11	White patches are seen on the surface of the concrete cube.
2.	M_{12}	8.280	8.45	2.053	

Table 9. Results of Compressive Strength of Specimens

S.No	Identification of specimen	Specimen no	Original compressive Strength of cube (N/mm^2)	Compressive Strength of cube after Sulphate attack (N/mm^2)
1	M3	1	32.70	33.70
2	M12	2	32.70	33.70

7. Conclusion

- The strength and durability of concrete can be improved by adding mineral admixtures (fly ash and silica fume).
- When concrete is exposed to acid, the structural components of the concrete deteriorate rapidly. As a result, life is exceedingly brief. Mineral admixtures must be used in order to extend the life of concrete constructions exposed to an acidic environment.
- The ingress of chloride ions into the concrete pores causes significant corrosion of the embedded reinforcement. There is no chance of the steel bars corroding if the concrete is impermeable.
- When the concrete is exposed to a Sulphate environment (when ground soil contains an excessive amount of Sulphate), the Sulphate solution reacts with the chemistry of the concrete and makes a weak structure.

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