International Journal For Technological Research In Engineering
Volume 5, Issue 11, July-2018 *ISSN (Online): 2347 - 4718*

EFFECT OF FLY ASH AND SILICA FUME AS PARTIAL REPLACEMENT OF CEMENT

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ABSTRACT: Concrete is the most versatile construction material because it can be designed to withstand harshest environments while taking on the most inspirational forms. Abstract Rapid growth of construction activities leads to active shortage of conventional construction materials due to various reasons. Cement, fine aggregate and coarse aggregate are the constituents of the concrete. Researches were searching for cheaper & eco-friendly materials as a replacement of cement in concrete. Nowadays, most concrete mixture contains supplementary cementitious material which forms part of the cementitious component. The main benefits of SCMs are their ability to replace certain amount of cement and still be able to display cementitious property, thus reducing the cost of using Portland cement. The fast growth in industrialization has resulted in tons and tons of by-product or waste materials,which can be used as SCMs such as Fly Ash, Silica Fume, Ground Granulated Blast Furnace Slag, Steel Slag, etc. The use of these by-products not only helps to utilize these waste materials but also enhances the properties of concrete in fresh and hardened states. To design high strength concrete good quality aggregates is also required.

To enhance the strength properties of the ordinary Portland cement (OPC), industrial by products such as Fly Ash and Silica Fumes can be utilized. The effect of Silica Fumes and Fly Ash as a partial replacement of Ordinary Portland Cement on compressive strength has been studied. To study this properties of concrete, the water cement ratio of 0.45 was taken. Five types of mix proportions were used to cast the test specimens for both groups. The replacement levels of OPC by fly ash and silica fumes were 0%, 6%, 8%, 10%, 12% . All these specimens are tested for 7 days and 28 days strength.

I. INTRODUCTION

The word concrete comes from Latin word “concretus” meaning compact or condensed. Concrete is a composite material composed of gravels or crushed stones (coarse aggregate), sand (fine aggregate) and hydrated cement (binder).For concrete to be good concrete it has to be satisfying in its hardened state and in its fresh state while being transported from the mixer and placed in the formwork. The requirements in the fresh state are that the consistence of the mix is such that the concrete can be compacted and also that the mix is cohesive enough to be transported and placed without segregation. As far as the hardened state is considered, the requirement is a satisfactory compressive strength. Concrete achieves its strength after 28days of placing the concrete. Concrete is a mixture of cement, sand, coarse aggregate and water. Its success lies in its versatility as can be designed to withstand harshest environments while taking on the most inspirational forms. Any construction activity requires several materials such as concrete, steel, brick, stone, clay, mud, glass, wood and many more. However, the cement concrete remains the main construction material used in construction industry. For its suitability and adaptability with respect to the changing environment, the concrete must be such that it can conserve resources, protect the environment and at the same time be economic too. To achieve this, major emphasis must be laid on the reuse of by-products or waste materials from industrial processes. The cement industry is held responsible for some of the carbon dioxide emission, because in the production of one ton of Portland cement, approximately one ton of carbon dioxide gas is emitted into the atmosphere. The emission of carbon dioxide will increase the effect of global warming due to the emission of greenhouse gases. Among the greenhouse gases, carbon dioxide contributes about 65% of global warming.

The usage of silica fumes and fly ash to partially replace the cement is because the production of cement emits carbon dioxide gas to the atmosphere. Engineers and scientists are further trying to increase its limits with the help of innovative chemical admixtures and various supplementary cementitious materials SCMs.

More recently, strict environmental – pollution controls and regulations have produced an increase in the industrial Wastes and sub graded by-products which can be used as SCMs such as fly ash, silica fumes, ground granulated blast furnace slag etc. The use of SCMs in concrete constructions not only prevents these materials to check the pollution but also to enhance the properties of concrete in fresh and hydrated states.

II. SUPPLEMENTARY CEMENTING MATERIALS

Supplementary cementing materials (SCMs) contribute to the properties of hardened concrete through hydraulic or pozzolanic activity. Typical examples are fly ashes, slag cement (ground, granulated blast-furnace slag), and silica fume. These can be used individually with portland or blended cement or in different combinations. Supplementary cementing materials are often added to concrete to make concrete mixtures more economical, reduce permeability, increase strength, or influence other concrete properties. Supplementary cementitious materials offer sustainable and performance advantages for those who build and occupy structures of all kinds. The growing use of these environmentally friendly materials is due in part to numerous performance factors, including improved workability and consolidation, flexural and compressive strengths, pumpability, resistance to chlorides and sulfates, lower temperatures for mass concrete, mitigation of alkali silica reaction, and decreased permeability.The use of cementitious blends not only results in stronger, more durable high-performance concretes, but also helps reduce global climate impact by lowering energy consumption and greenhouse gas emissions.

FLY ASH

Fly ash is a fine powder byproduct from industrial plants using pulverized coal or lignite as fuel .It is the most widely used pozzolona siliceous or aluminosiliceous in nature in a finely divided form .They are spherical shaped “balls’’ finer than cement particles.

SOURCES OF FLY ASH

Fly ash is powder recovered from the gases of coal fired electricity production Inexpensive replacement of Portland Cement Improves strength, segregation and ease of pumping the concrete.

USES OF FLY ASH

Fly ash is used as a supplementary cementitious material (SCM) in the production of portland cement concrete. When used in portland cement improve properties of the hardened concrete. SCM's include both pozzolans and hydraulic materials.

EFFECT OF FLY ASH ON IMPORTANT PROPERTIES OF CONCRETE The addition of fly ash to cement has been found to enhance cement properties:

- Normal consistency increases with increase in the grade of cement and fly ash content.
- Workability increases in fly ash concrete.
- As the fly ash contents increases in all grades of OPC there is reduction in the strength of concrete.
- In all grades OPC, fly ash concrete is more durable as compared to OPC concrete and fly ash up to 40% replacement increase with grade of cement.
- Shrinkage of fly ash concrete is similar to the pure cement concrete in all grades of OPC.
- High compressive and split tensile strengths at certain %age of fly ash added.

SILICA FUME

Silica fume is also known as micro silica, condensed silica fume, volatized silica or silica dust. It can be used in concrete and refractory materials. Microsilica, when used in concrete, it can improve concrete’s properties such as compressive strength, bond strength and abrasion resistance, reduces permeability It is usually a grey coloured powder, somewhat similar to Portland cement or some fly ashes. It can exhibit both pozzolanic and cementations properties.

SOURCES AND CHARACTERISTICS OF SILICA FUME

Silica fume is an artificial pozzolanic material, produced by the reduction of high quality quartz with coal in an electric arc furnace in the manufacture of silicon or ferro silicon alloy. Silica fume is, when collected, an fine powder having the following basic properties:

•It has at least 85% SiO_2.
•Particle size between 0.1 and 0.2 micron .
•Minimum specific surface of 15000m2/kg.
•Spherical particle shape.

USES OF SILICA FUME

The appropriate use of SF in concrete can give a range of benefits in design, construction and performance of many types of concrete structure – including high-rise buildings, industrial floors, civil engineering and marine structures. It can be used for precast and inside concrete. SF has specific benefits during construction, including:

- Increased cohesiveness of the fresh concrete.
- Lower permeability and improved durability.
- Greater resistance to abrasion and impact than conventional concretes of similar strength grade.
- SF can be used as an ingredient in high performance concretes containing micro-fibers to combat explosive spalling during exposure to fire, Environmental benefits (due to reduced cement contents and improved service life).
- SF is ideally suited to the most demanding applications, such as concrete slipways, dam spillways and hard standings, where chloride, chemical or abrasion resistance are required.
- High compressive and split tensile strength.
- Increased toughness.
- Higher bond strength.
- High electrical resistivity and low permeability.

III. EFFECT OF SILICA FUME ON IMPORTANT PROPERTIES OF CONCRETE

The addition of Silica Fume to cement has been found to enhance cement properties:

- The addition of Silica Fume speeds up setting time.
- At certain %age of replacement of Silica Fume cement has improved compressive strength due to its higher percentage of silica.
- More recent studies have shown Silica fume has uses in the manufacture of concrete for the marine environment. Replacing 15% Portland cement with Silica fume can improve resistance to chloride penetration.
- Several studies have combined fly ash and Silica Fume in various proportions. In general, concrete made with Portland cement containing both Silica Fume and fly ash has a higher compressive strength than concrete made with Portland cement containing either Silica Fume or fly ash on their own.

Physical and Chemical Properties of OPC, Silica Fume and Fly Ash

Properties	Ordinary Portland Cement	Silica Fume	Fly Ash
Specific Gravity	3.12	2.24	2.85
Fineness	370 m^2/kg	20400 m^2/kg	423 m^2/kg
Consistency	26 %	-	42 %
Initial Setting Time (min.)	27	-	-
Final Setting Time (min.)	529	-	-
Bulk Density	-	240 kg/m^3	-
SiO_2	21.02 %	91.4 %	53.92 %
Al_2O_3	5.68 %	1.1 %	21.0 %
Fe_2O_3	3.53 %	0.3 – 0.5 %	3.9 – 4.3 %
MgO	1.1 %	1.3 %	2.2 %
CaO	62.25 %	0.7 %	4.0 %
SO_3	3.0 %	-	0.6 %
Na_2O	0.15 %	0.8 %	-
K_2O	0.35 %	0.5 %	-
TiO	-	-	0.98 %
C	-	0.9 %	18.89 %
S	-	1.8 %	-
Loss of Ignition	1.05 %	2.4 %	1.9 %

IV. AIM AND OBJECTIVE

RESEARCH AIM

The aim of this study to make the High Performance Concrete by replacing cement with a waste material but super pozzolanic silica fume, fly ash. And to study the strength and workability of silica fume and fly ash concrete, through an experimental investigation.

RESEARCH OBJECTIVES

- To study the effect of partial replacement of cement with fly ash and silica fume.
- Evaluation of the compressive strength of fly ash and silica fume concrete.
- To find out the optimum percentage of replacement of fly ash and silica fume.
- To know the strength variations with use of fly ash and silica fume to the normal concrete.

SCOPE OF STUDY

The scope of the study is restricted to the following aspects.

- The workability, compressive strength of silica fume and fly ash concrete of different ratio, different mix proportions with constant water cement ratios have been investigated.
- High-performance concrete of grade M-25 is used and the replacement levels of cement by fly ash and silica fume are selected as 0%, 6%, 8%, 10%, 12% & 14% for standard sizes cubes for testing.

V. MATERIALS AND METHODOLOGY

MATERIALS USED

A. Cement: Ordinary Portland cement 43 grade is used in the project work, as it is readily available in local market. The cement used in the project has specific gravity was 3.15.

B. Coarse Aggregate: Crushed angular coarse aggregate were used. The specific gravity was 2.68. The coarse aggregate used in the project work are 20 mm down grade.

C. Fine Aggregate: River white sand was used as fine aggregate. The specific gravity was 2.65. The fine aggregate used in the project work is 4.75 mm down grade and zone III .

D. Silica fume: Silica fume is also known as micro silica, condensed silica fume, volatized silica or silica dust. It is usually a grey coloured powder, somewhat similar to Portland cement or some fly ashes. It can exhibit both pozzolanic and cementations properties.

E. Fly ash: Fly ash is powder recovered from the gases of coal fired electricity production Inexpensive.

F. Water: Combining water with a cementitious material forms a cement paste by the process of hydration. The cement paste glues the aggregate together, fills voids within it, and makes it flow more freely.

VI. METHODOLOGY USED IN EXPERIMENTS

The research process would consists of variousus steps which may be include as below :

- Collection of materials.
- Preliminary tests.
- Mix design of M25 was prepared.
- Batching , mixing , casting and curing.
- Result and discussion.
- Conclusion.

TEST METHODS

Tests On materials: Various tests on materials were conducted which are given below:

Fineness test of cement, consistency of cement, initial and final setting time of cement, compressive strength test of cement, gradation of coarse aggregate, crushing value test of coarse aggregate, sieve analysis and water absorption test of fine aggregate.

Workability: The workability tests were performed using standard sizes of Slump Moulds
1) Slump Test
C. Compressive Strength: The Steel mould of size 150 x 150 x 150 mm is well tighten and oiled thoroughly, then tested in 7, 28 days.

MIX PROPORTIONS OF FLY ASH AND SILICA FUME

Mix	Fly ash and Silica Fume %
M1	0
M2	6
M3	8
M4	10
M5	12

Fly Ash And Silica Fume %

In every mix proportions of fly ash and silica fume concrete, there is 70% of fly ash and 30% of silica fume.

QUANTITIES OF MATERIALS USED IN VARIOUS FLY ASH AND SILICA FUME MIX PROPORTIONS.

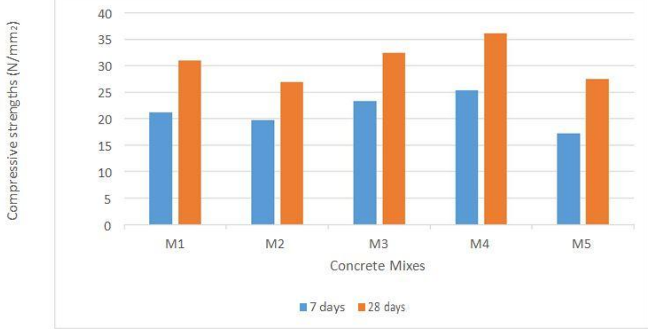
Mix	Silica Fume and fly ash%	Fly ash	Silica fume	Cement (kg)	Fine Aggregate (kg)	Coarse Aggregate (kg)	Water (kg)	Mix Ratio
M1	0	-	-	1.44	2.10	3.95	0.64	1 : 1.46 : 2.75
M2	6	0.060	0.025	1.35	2.10	3.95	0.64	1 : 1.46 : 2.75
M3	8	0.080	0.034	1.32	2.10	3.95	0.64	1 : 1.46 : 2.75
M4	10	0.098	0.042	1.30	2.10	3.95	0.64	1 : 1.46 : 2.75
M5	12	0.119	0.051	1.27	2.10	3.95	0.64	1 : 1.46 : 2.75

VII. RESULTS AND DISCUSSIONS

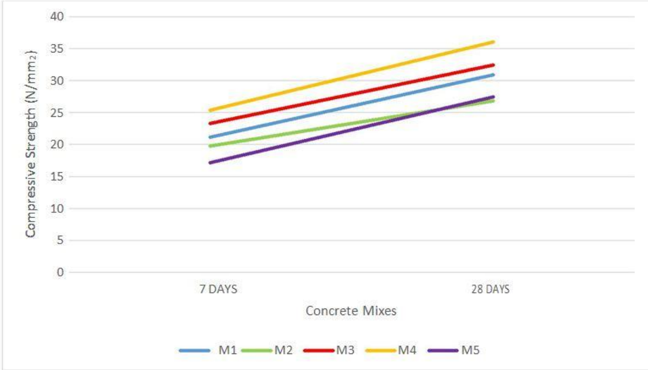
COMPRESSIVE STRENGTH TEST RESULTS:

MIX	DAYS	COMPRESSIVE STRENGTH (N/mm^2)
M1	7	21.172
	28	30.96
M2	7	19.79
	28	26.88
M3	7	23.32
	28	32.49
M4	7	25.37
	28	36.11
M5	7	17.23
	28	27.47

VARIATION OF COMPRESSIVE STRENGTH OF FLY ASH AND SILICA FUME CONCRETE IN N/mm2 W.R.T. NORMAL M25 CONCRETE:



VARIATION OF COMPRESSIVE STRENGTH OF FLY ASH AND SILICA FUME CONCRETE IN N/mm2 FOR DIFFERENT MIX PROPORTIONS:



VIII. CONCLUSION

The conclusion drawn from the comparative study of effect of fly ash and silica fume as partial replacement of cement is given below:

- The compressive strength of fly ash and silica fume concrete is found to be more than that of conventional concrete for a mix of 90% cement and 10% fly ash & silica fume and 92% of cement and 8% of flyash & silica fume.
- The Silica Fume occupies more volume than cement same weight. So the total volume of the silica fume concrete increases for a particular weight as compared to conventional concrete.
- When the percentage of the silica fume is increased, the workability of the mix becomes very poor as compared to the conventional concrete.
- Fly ash and silica fume can be added to concrete by 8% & 10% as the strength was increasing than conventional concrete.
- As the strength is increased at an addition of 8% & 10% fly ash and silica fume , therefore cement content is saved which in turns saves the concrete cost because less amount of cement quantity is used in concrete mix design. Hence, decreases the project cost and makes the project eco- friendly.

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