EXPERIMENTAL INVESTIGATION STRENGTH PROPERTIES OF CONCRETE INCORPORATING FLYASH AND SILICA FUME IN CEMENT AND REPLACING RIVER SAND BY FOUNDRY SAND AND M-SAND

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Abstract - *Sand mining is a current problem faced by the construction industry in the present day. Hence there is a need to identify suitable alternatives to natural river sand as fine aggregate in concrete to cater the future demand of fine aggregate. Foundry sand, a waste product obtained from metal foundry is identified as a potential replacement to river sand. The present investigations are focused on fly ash concrete mixes incorporating foundry, M sand as fine aggregate. In this study, the strength and durability properties with incorporating of cement with fly ash and silica fume with different levels of replacement (0%, 10%, 20%, 30%, 40%, and 50%) of river sand with foundry sand and M - sand are evaluated. The present study will address the disposal related problem of fly ash and foundry sand, thus reducing environmental hazards and also will lead to the conservation of natural fine aggregate for future.*

1.INTRODUCTION

Concrete is one of the most widely used construction materials it is usually associated with Portland cement as the main component for making concrete. The demand for concrete as a construction material is on the increase. On the other hand, the climate change due to global warming, one of the greatest environmental issues has become a major concern during the last decade. The global warming is caused by the emission of greenhouse gases, such as CO2 to the atmosphere by human activities. Among the greenhouse gases, Co2 contributes about 65% of global warming. The cement industry is responsible for about 6% of all Co2 emissions, because the production of one ton of Portland cement emits approximately one ton of CO2 into the atmosphere. Many efforts are being made in order to reduce the use of Portland cement in concrete. These efforts include the utilization of supplementary cementing materials such as fly ash, silica fume, granulated blast furnace slag, rice-husk ash and metakaolin, and finding alternative binders to Portland cement. In this research work, the fine aggregate is replaced by the M sand and Foundry sand by 0%, 10%, 20%, 30%, 40%, and 50% in M30 grade concrete.

In recent times, many researches are going on for improving the properties of concrete with respect to strength, durability, and performance as a structural material. There are many materials like fly ash, furnace slag, foundry sand and silica fume etc. One among these special concrete is the foundry sand which is new emerging as one of new generation construction material in producing high strength and performance concrete for special structures. The interest in fly ash and ground granulated blast furnace slag started in enforcement of air pollution control in many countries. This implies that the industry had to stop releasing fly ash and foundry sand into the atmosphere. available and lesser cost compared to naturally available river sand. The obtained waste by-product can be recycle and reuse many times till it is no longer reused and it is termed as waste foundry sand (WFS).

2. SCOPE AND OBJECTIVE

A. Objective

The objective of the project is to investigate the development of concrete strength using the investigation is also aimed at finding out the optimum grade of concrete for superior strength while using silica fume, fly ash and M sand, foundry sand.

- To evaluate the utility of silica fume & fly ash incorporating of cement in concrete.
- The effect of adding foundry sand and M sand to concrete to improve the properties of concrete.
- The benefits of addition silica fume and fly ash is to minimize the risk of the Environmental Pollution.
- To study and compare the performance of conventional concrete and silica fume & fly ash, foundry sand and M sand concrete.
- To study the strength and workability of silica fume and fly ash concrete, through an experimental Investigation.

B. Scope

To evaluate the recyclability of fly ash, silica fume as a pozzolana as partial replacement of cement and waste foundry sand, M sand as partial replacement of fine aggregate in the concrete.

- To achieve 28 days characteristic compressive strength
- To study the compressive strength of silica fume, fly ash + M sand, foundry sand concrete and conventional concrete.
- To carry out the comparative study of compressive strength of silica fume, fly ash + M sand, foundry sand concrete and conventional concrete.
- To study the effect on workability, and strength properties of concrete mix with varying grades of concrete by replacing of sand by M sand, foundry sand and cement by silica fume, fly ash.
- To find out optimum grade of concrete at which the concrete yields superior mechanical properties.
- To achieve better concrete composite and to encourage the use of glass powder and granite powder to overcome the environmental impact caused due to waste disposal and over depletion of river sand.

3. MATERIALS

This chapter presents the details of materials for concrete and the mix designs for performing the experimental study.

The materials to be used for the experimental study are detailed as follows.

1. Cement
2. Fine aggregate
3. Coarse aggregate
4. Water
5. Silica fume
6. Fly ash
7. Foundry sand
8. M sand

A. Cement

Ordinary Portland cement (OPC) 53grades in one lot was produced and stored in air tight container. The cement used was fresh, used within three months of manufacture. It should satisfy the requirements of IS10262. The property of cement is determined as per IS4031:1968.

TABLE 1 Typical composition of OPC

S.NO	Chemical properties	% by mass
1	Lime	62
2	Silica	22
3	Alumina	5
4	Calcium Sulphate	4
5	Iron Oxide	3
6	Magnesium Oxide	1
7	Sulphur Trioxide	1
8	Alkalis	1

B.FINE AGGREGATE

Fine aggregate used in this investigation was Medium sand properties of the fine aggregate used in the experimental work. Advantage of natural sand is that the particles are cubical or rounded with smooth surface texture. The grading of natural fine aggregate is not always ideal. It depends on place to place. Being cubical, rounded and smooth textured it gives good workability. Aggregates are the important constituents in concrete. They give body to the concrete, reduce shrinkage and effect economy. One of the most important factors for producing workable concrete is good gradation of aggregates. Good grading implies that a sample fractions of aggregates in required proportion such that the sample contains minimum voids. Samples of the well graded aggregate containing minimum voids require minimum paste to fill up the voids in the aggregates. Minimum paste means less quantity of cement and less water, which are further mean increased economy, lower shrinkage and greater durability.

TABLE 2 properties of fine aggregate

PROPERTIES	FINE AGGREGATE
Shape	Angular
Gradation zone	Zone II
Specific gravity	2.50
Fineness modulus	2.95

C.COARSE AGGREGATE

Locally available in coarse aggregates having the maximum size of 10 mm and 20 mm were used in the present work. Coarse aggregate is chemically stable material in concrete.

TABLE 3 properties of coarse aggregate

S NO.	Properties	Values
2	Specific gravity	2.60
3	Total water absorption	0.8%
4	Fineness modulus	10%
5	Impact value	29.2%
6	Crushing value	18.39%
7	Flakiness index	12.84%
8	Elongation index	16.43%

D.SILICA FUME

Silica fume is considered as the most efficient micro filler for high performance concrete. Its two fold effects are reduction of w/c ratio and increases of hardened concrete. The silica fume used in this study was in the powder form and contained 95% SiO, 0.39% 2CAO, 0.21% MgO, 0.11% KO, 0.15% NaO, 0.13% AlO, 40% FeO The properties of silica fume result in more efficient gel.

Silica fume is a very fine non-crystalline sio2, is a byproduct of ferro-silicon industry. It is made at a temperature of approximately 2000 c. it size is about 0.1μm. Compared to cement, the particle size of silica fume is 2 orders finer. It acts as an excellent pore- filling material. It can be used in proportions of 5 – 10% of cement content in a mix. Silica fume of its extreme fineness and high silica content is a highly silica content is a highly effective pozzolonic material. Silica fume reacts pozzolanically with the calcium hydroxide during the hydration of cement to form the stable cementitious compound calcium silicate hydrate (C-S-H) gel.

Picture for Silica fume

E.FLY ASH

Fly ash is the most widely used pozzolanic material all over the world. In the recent time, the importance and use of the fly ash in concrete has grown so much that it has almost become a common ingredient in concrete, particularly for making high strength and high performance concrete. High volume of fly ash concrete is a subjected of current interest all over the world.

The use of fly ash as concrete admixture not only extents technical advantages to the properties of concrete but also contributes to the environmental pollution control.

Picture for Fly ash

TABLE 4 Chemical Composition of fly ash

S.NO	Chemical Constituents Of Fly ash	% by mass
1	Silica	50.41
2	Alumina	30.66
3	Potassium oxide	0.31
4	Iron oxide	3.34
5	Magnesium oxide	0.93
6	Sulphur Trioxide	1.71
7	Sodium oxide	3.07
8	Lime	3.04
9	Tio_2	0.84

F.FOUNDRY SAND

Foundry sand is produced by five different foundry classes. The ferrous foundries (grey iron, ductile iron and steel) produce the most sand. Aluminium, copper, brass and bronze produce the rest. While the sand is typically used multiple times within the foundry before it becomes a by-product, only 10 percent of the foundry sand was reused.10 million tons of foundry sand can beneficially be used annually. Foundry sand is high quality silica sand with uniform physical characteristics. It is a by-product of ferrous and non-ferrous metal casting industries.

Picture for foundry sand

TABLE 5 Physical properties of foundry sand

S NO	Properties	Results
1	Specific gravity	2.39 – 2.55
2	Bulk relative density	2590 kg/m^3
3	Absorption	0.45%
4	Moisture content	0.1 – 10.1%
5	Clay lumps and friable particles	1 – 44
6	Coefficient of permeability	10^{-3} – 10^{-6} cm/sec
7	Plastic limit	Non plastic
8	Plastic index	Non plastic

G. M – SAND

Manufactured sand is an alternative for river sand. Due to fast growing construction industry, the demand for sand has increased tremendously, causing deficiency of suitable river sand in most part of the world. A fine aggregate produced by crushing of stone or natural gravel to be used as an alternate of natural sand is called as manufactured sand.The cubical-shaped M-sand has a surface that gives better binding strength and saves cement. Manufactured sand is totally inert material and its physical properties are similar to natural sand. M-Sand can be used as a partial replacement for fine aggregate, the use of manufactured sand as a construction raw material neither imposes risks to the human kind nor to the environment. Specific gravity of M-Sand is 2.75 and fineness modulus is 2.74.

H. WATER

The potable water available in college campus was used for mixing and curing of concrete. Water helps in dispersing the cement even, so that every particle of the aggregate is coated with it and brought into ultimate contact with the ingredients. It reacts chemically with cement and brings about setting and hardening of cement .It lubricates the mix and compact properties. The quality of water was found to satisfy the requirement of IS456-2000.

4. MIX DESIGN

The mix shall be designed to produce the grade of concrete having the required workability and the characteristic strength. The properties are either by volume or by mass. The water-cement ratio is usually expressed in mass.

A. Factor to be considered

- The grade designation giving the characteristic strength requirement of concrete.
- The type of cement influences the rate of development of compressive strength of concrete.
- Maximum nominal size of aggregates.
- The cement content is to be limited from shrinkage, cracking and creep.
- The workability of concrete and maximum temperature of concrete at the time of placing.

B. Casting and Curing

The main objective of the test program is to study the strength characteristic of concrete with replacement of Silica Fume and Fly ash. The main parameters were studies the compressive, Split tensile and Flexural strength.

1. Casting of cubes

Initially the constituent materials were weighed and dry mixing was carried out for Cement, Fine aggregate, Coarse aggregate, Silica Fume and Fly ash, M sand. The was thoroughly mixed manually to get uniform colour of mix. The mixing was carried out for 3-5 minutes duration. Then the mix poured in to the cube moulds of size 150x150x150mm and then compacted manually using taming rods. Cubes are prepared by using the mixes of M30 Grade namely conventional concrete and concrete made by replacing 10%, 20%, 30%, 40%, 50% of Silica Fume, Fly ash, M sand and Foundry sand.

2.Casting of cylinders

Initially the constituent materials were weighed and dry mixing was carried out for Cement, Fine aggregate, Coarse aggregate, Silica Fume, Fly ash, M sand, Foundry sand. This was thoroughly mixed manually to get uniform colour of mix. The mixing was carried out for 3-5 minutes duration. Then the mix poured in to the cylinder mould by layer by layer and each layer effectively compacted by the cylinder of 150mm dia and 300mm height were casted for each design mixes.

3.Casting of RCC Beams

The concrete mixes were filled in the Beam moulds after laying the reinforcements with the required cover and compacted effectively by using damping rod. The beams dimensions 700x100x100mm were casted for each design mixes.

4.Curing

The Cubes, Cylinders and Beams are de-moulded after 1 day of casting and then kept in water for curing at normal temperature. The concrete specimens are taken out from curing tank after 7days, 14days and 28days for testing. Curing is a procedure that is adopted to promote the hardening of concrete under condition of humidity and temperature which are conducive to the progressive and proper setting of the constituent cement. They should be sent to the testing laboratory well packed in damp sand, damp sacks, or other suitable material so as to arrive there in a damp condition not less than 24 hours before the time of test Concrete that has been specified, batched, mixed, placed, and finished can still be a failure if improperly or inadequately cured.

C. Testing Of Specimens

The following tests are conducted to the casted concrete specimens.

1.Compressive Strength Test: The tests were carried out on 150x150x150mm size cube, The compression test is the most common test conducted on the hardened concrete, partly because it is an easy test conducted on the and partly because most of the desirable characteristic properties of concrete are qualitatively related to its compressive strength. The compressive test is carried out on specimens cubical or cylindrical in the shape. The specimen was placed between the steel plates of the compression-testing machine. The load is applied and the failure load in KN is observed from the dial gauge of the Compression Testing Machine. The compression test on cubes was conducted according to Indian Standard specifications. The compressive strength of the cube specimen is calculated using the following formula: Compressive Strength, fc=P/A N/mm^2.

2. Split Tensile Strength Test: A direct measurement of ensuring tensile strength of concrete is difficult. This is an indirect tensile test. The split tensile strength test was carried out on the universal testing machine. The split tensile strength of the cylinder specimen is calculated using the following formula:

split Tensile Strength, f =2p/ΠDL N/mm^2

Where, P = Load at failure in N

L = Length of the Specimen in mm

D = Diameter of the Specimen in mm

3.Flexural Strength Test: Flexural strength, also known as modulus of rupture, bending strength or fracture strength a mechanical parameter for brittle material, is defined as a material's ability to resist deformation under load. The value of modulus of rupture depends on the dimension of the beam and type of loading. The loading is central or third – point loading. In the third –point the critical crack may appear at any section, where the bending moment is maximum or the resistance is weak. The flexural strength represent the highest stress experienced with in material at terms of stress, here given the symbol calculated using the following formula:

The flexural strength when a >133 mm for 100 mm specimen, f fb = Pa/bD^2

The flexural strength when a < 133 mm for 100 mm specimen, f fb = $3Pa/bD^2$

b = measured width of specimen in mm

D = measured depth in mm of the specimen at the point of failure.

a = distance of the crack from the nearer support in mm

P = maximum load in N applied to the specimen.

5. RESULTS AND DISCUSSIONS

A.COMPRESSIVE STRENGTH

Compressive strength of concrete is the one of most important property of the hardened concrete. The concrete cubes were casted and tested accordance with the IS standard and 7, 14 and 28 days. Compressive strength results of concrete .The highest compressive strength value is 39.18 Mpa which is obtained at 28 days for M 30 grade by replacement of 10% ,20% ,30% ,40% 50% M sand ,fly ash, silica fume , foundry sand. Curing periods for the various mixes. The compressive strength is gradually increased when the grade of concrete is increased. Maximum Compressive strength of cube is found to be 39.18 Mpa silica fume , foundry sand ,replaced with cement and fine aggregate with M sand , foundry sand respectively in concrete and it increased the compressive strength by 11% than conventional concrete .

B.SPLIT TENSILE STRENGTH

After curing of Cylinder specimen they are placed in testing machine. The load is applied on the cylinder specimens. The cylinder specimen is failed at ultimate load which is noted from dial gauge reading. From the result.

Split tensile strength is most important property of the hardened concrete. The concrete cylinders were cast , cured and tested accordance with the IS standard and 7 ,14 and 28 days split tensile strength results of concrete. Based on the result , the highest split tensile strength value is 7.0 Mpa (for M 30) which is obtained at 28 days by replacement of 10% , 20% , 30% , 40% , 50% M sand , fly ash ,foundry sand, silica fume .the split tensile strength of concrete for various mixes . Strength is increased 16.2% than the conventional concrete.

C.FLEXURAL STRENGTH

After curing of beam specimen they are placed in testing machine having a maximum capacity of 40 tonne. The load is applied on the beam specimens. The specimen is failed at ultimate load which is noted from dial gauge reading. From the result flexural strength is increased with respect to the grade of concrete when adding 10% , 20% , 30% , 40% , 50% , of M sand ,fly ash, foundry sand, silica fume, when compared to the conventional concrete .

Flexural strength is property of the hardened concrete . The RCC Beams were casted , cured and tested accordance with IS standard and 7, 14, and 28 days flexural strength result of concrete are listed in table VIII

3. SUMMARY AND CONCLUSION

In this project the test results and the following conclusion have been drawn.

1. The compressive strength of mixed fly ash, silica fume, foundry sand and M sand concrete was higher than the conventional concrete.

2. Compressive strength increases with increases of % of mixed materials.

3. The flexural strength of mixed fly ash, silica fume, foundry sand and M sand concrete was higher than the conventional concrete.

4. Flexural strength increases with increases of % of mixed materials.

5. Initial crack increases with increases of % of mixed materials.

6. Young's modulus increases with increases of % of mixed materials.

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