# Comparative Study on Strength Properties of Conventional Concrete with Binary Cement Concrete

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**Abstract –** *The utilization of innovative material becomes mandatory in recent days due to developing population, which is now a great challenge to the society, because of the scarcity of materials. The most important part of concrete is cement. In concrete the price of cement is higher than other raw materials. The production process of cement produces a lot of $CO_2$. The enormous emission of $CO_2$ initiates harmful environmental changes. Nowadays researchers make efforts to minimize industrial emission of $CO_2$. This major problem can be solved by replacing the material to some extent with advance materials or by making alterations in the property of the conventional concrete. The current paper is an experimental work carried out to assess the comparative study of Binary cement concrete and Conventional Concrete in terms of their Compressive Strength, flexural strength ,split tensile strength parameter. M40 grade of Concrete was designed to carry out this experimental test. Testing the properties of concrete by partial replacement of cement with silica fume was made based on the Water Submerged Curing.It would be difficult to produce concrete mixtures without using chemical admixtures. The super plasticizer gives the concrete adequate workability at low water- cement ratios, leading to concrete with greater strength. Optimal dosages of plasticizing admixtures and silica fume were estimated and the most efficient method of silica fume adding to concrete mixture was proposed.*

***Key Words*: Binary cement concrete, Compressive Strength, Split tensile strength, Flexural strength, Silica fume, Chemical admixture.**

## I.INTRODUCTION

Concrete is a most frequently used building material which is a mixture of cement, sand, coarse aggregate and water. As we know the manufacturing process of cement and aggregate causes huge environmental impact, and day by day this increasing demand of concrete materials is ultimately causing impact to our environment. Thus replacing cement (conventional constituents of concrete) can in turn help in minimizing the environmental impact caused during manufacturing process of cement. Ordinary portland cement is used as binder material for constructing Buildings. Now a days many people are engrossed on the usage of different waste materials having Cementious properties which can be partially replaceable in cement, without negotiating its strength. Pozzolanic admixtures like Silica Fume having cementitious properties can be partially replaceable in cement. The optimistic outcomes of such materials used in concrete increases demand for cementitious materials. The main objective of this research is to compare conventional concrete and binary cement concrete in terms of compressive strength, split tensile strength, flexural strength. To check the strength property the Conventional Concrete cubes and binary cement concrete cubes were cured by Water Submerged Curing method. The curing of concrete cubes was carried out for 7 days, 14 days and 28 days subsequently and cubes were tested respectively. The grade of concrete used use cast all the set of cubes was M40 with w/c ratio 0.40.Silica fume, a very active mineral admixture, is used in production of high strength for concrete. Due to a very active pozzolanic effect silica fume increases concrete strength, although due to their great specific surface area, it also considerably increases the water demand in concrete mixture, therefore using silica fume it is important to increase considerably the amount of plasticizing admixture in the concrete. The influence of complex admixtures, being composed from polycarboxyl ether superplasticizers and lignosulfonates as well as silica fume, on cement mixtures and concretes properties determines strength of concrete.

## II. MATERIALS

**1.Cement**: Ordinary Portland cement (OPC) Of 53 grades satisfying the requirements of IS: 8112- 1939 is used. OPC is the most common cement used in general concrete construction manufactured by grinding a mixture of limestone and other raw materials. Following table 1 gives the properties of cement tested.

**Table 1: Properties of Cement**

| PROPERTIES | TEST RESULTS | RANGES |
|---|---|---|
| Fineness | 8.9% | 0-10% |
| Specific Gravity | 3.18 | 3.15 -3.19 |
| Standard Consistency | 32% | 26-33% |
| Initial Setting Time | 50 Min | not less than 30 min |
| Final Setting Time | Min | not more than 600 min |

**2.Fine Aggregates(FA):** Fine aggregate (M sand) confirming to IS 383:1970 used in this study was locally procured. Manufactured sand(M-sand) is sand produced from hard rock by crushing. The size of M-sand is less than 4.75mm. Physical properties of FA are given in table 2 below.

**Table 2: Properties of Fine Aggregates(M sand)**

| PROPERTIES | TEST RESULTS | RANGES |
|---|---|---|
| Fineness Modulus | 2.9 | 2.6 -3 |
| Specific Gravity | 2.5 | 2.5- 2.9 |
| Bulk density | 1.39 g/cc | - |
| Void ratio | 0.48 | - |
| porosity | 29.34% | - |

**3.Coarse Aggregates (CA):** Coarse aggregates of maximum size of 20mm were used in this study. The coarse aggregate is the strongest and least porous component of concrete. Coarse aggregate in cement concrete contributes to the heterogeneity of the cement concrete and there is weak interface between cement matrix and aggregate surface in cement concrete The aggregates used were confirming to IS 383:1970. The properties of CA are given in table 3 below.

**Table 3 : Properties of Coarse Aggregates**

| PROPERTIES | TEST RESULTS | RANGES |
|---|---|---|
| Fineness Modulus | 3.125 | 2.9-3.2 |
| Specific Gravity | 2.97 | 2.5-3.0 |
| Water Absorption | 0.324% | 0.1-2.0% |
| Bulk density | 1.811g/cc | - |
| Void ratio | 0.257 | - |
| porosity | 46.6% | - |

**4.Silica Fume:** It is waste by product in the manufacturing of elemental silica. Also referred as micro silica or condensed silica . It is a pozzolanic material having size less than 1μm and spherical shape, this is an ultrafine material. Micro silica consist of fine element with a surface area on the order of 215,280 $ft^2$/lb (20,000 $m^2$/kg). It is of white colour. Micro silica is added to Portland cement concrete to enhance its properties, in particular its compressive strength, bond strength, and abrasion resistance. Addition of silica fume decrease the permeability of concrete to chloride ions, which protect the reinforcing steel of concrete from corrosion, especially in chloride rich environment such as coastal region. Due to its high surface area, high pozzolanic action and its chemical properties it has both engineering as well as economical benefits. The various physical properties of silica fume are given in table 4 below.

**Table 4 : Properties of Silica Fume**

| PROPERTIES | TEST RESULTS | RANGES |
|---|---|---|
| Fineness | 8.31% | 0-10% |
| Specific Gravity | 3.149 | 3.15 -3.19 |
| Standard consistency | 27.50% | 26 -33% |

**5.Chemical Admixtures:**

a) Superplasticizers: Superplasticizers are chemical admixtures, known as high range water reducers which are added to the batch during mixing. The superplasticizer used in the work is Polycarboxyl ether superplasticizer(PCE). PCE shows extremely high water reduction in concrete with improved workability and increase in strength. They allow a water reduction up to 40% with a relatively low dosage.

b) Plasticizer: A plasticizer is an additive used to improve the plasticity of a certain substance. The superplasticizer used in the work are Lignosulphonate plasticizer(LSP).LSP works as retarders and plasticizer in construction,which is anionic surface active substance,on the adsorption and dispersion of cement, concrete can improve various physical performance.

**6.Water:** Water is also a very important element in concrete as it is responsible for the hydration of cement in concrete. Water quality and quantity should be carefully observed as it helps in producing strength giving cement gel.Normal consumable water is generally suitable for concrete. In present study we have used water for mixing as well as for curing.

**7.Mix Design:** Mix design of M40 concrete has been prepared as per the provisions of IS 10262:2009. This mix is prepared by keeping water cement ratio constant.

**Table 7 : Mix Design (M40)**

| Units | Cement (kg) | FA (kg) | CA (kg) | Water (kg) | Admixture (kg) | W/C |
|---|---|---|---|---|---|---|
| $m^3$ | 385 | 837 | 1077 | 154 | 4 | 0.40 |
| Ratio | 1 | 2.1 | 2.7 | 0.40 | 0.01 | |

## III. METHODOLOGY

The methodology adopted to accomplish the objective of the experimental investigation and execution of work was done in step by step as follow:

1) Weighing- The quantity of all ingredients of the concrete i.e. cement, silica fume, fine aggregate, coarse aggregate, chemical admixtures and water for each batch was determined as per the mix design ratio and weighed using weighing machine available in laboratory.

2) Mixing- Process of mixing of various ingredients adopted was as per IS: 516-1959 and hand mixing process was adopted for mixing the concrete.

3) Preparation of moulds- Before casting the specimens, all cube, beam and cylinder moulds were cleaned, screwed tightly and oil was applied to all surfaces to prevent adhesion of concrete during casting.

4) Compaction- Placing of concrete in oiled moulds was done in three layers and each layer tamped 25 times with the tamping rod. After tamping the moulds, they were compacted using vibratory machine.

5) Curing- After 24 hours, all the casted specimens were De moulded from the moulds and marked (to identify the casting batch) and immediately put into the curing tank for a period of 7, 14 and 28 days for different specimens. The specimens were not allowed to become dry during the curing period.

6) Testing- Specimens were taken out from the curing tank after 7, 14 and 28 days to perform various tests. Three numbers of specimens in each sample were tested and the average value was calculated. Fresh concrete property like workability was examined during casting by slump cone test, vee-bee consistometer test, compaction factor test. Hardened properties were found out by carrying out the investigational work on cubes, beams and cylinders which were casted in laboratory and their behaviour under test were observed at 7, 14 & 28 days for compressive strength, flexural strength and split tensile strength.

## IV. RESULT AND DISCUSSION:

All work is carried out in single stages, result of all stage is presented in graphical form. Tests are performed on cubes, beams & cylinders and their 7 days, 14 days & 28 days strengths have been determined. A comparison of strengths for 7 days, 14 days and 28 days are also formulated.

### 1. Compressive Strength:

The results of the compressive strength tests conducted on concrete specimens of different mixes cured at different ages are presented and discussed in this section. The compressive strength test were conducted at curing ages of 7, 14, and 28, days. Variation of compressive strength of all the mixes cured at 7, 14, and 28, days are also shown in Graphs which shows the variation of compressive strength of concrete mixes w.r.t control mix (100% OPC & different % S.F) after 7, 14, and 28 days respectively.Test specimens of size 150mm×150mm×150mm were prepared for testing the compressive strength concrete. The concrete mixes of varying percentages 0%, 3%, 5%, 7%, 9%, 11%, 13%, 15% of silica fume as partial replacement of cement were cast into cubes for subsequent testing.

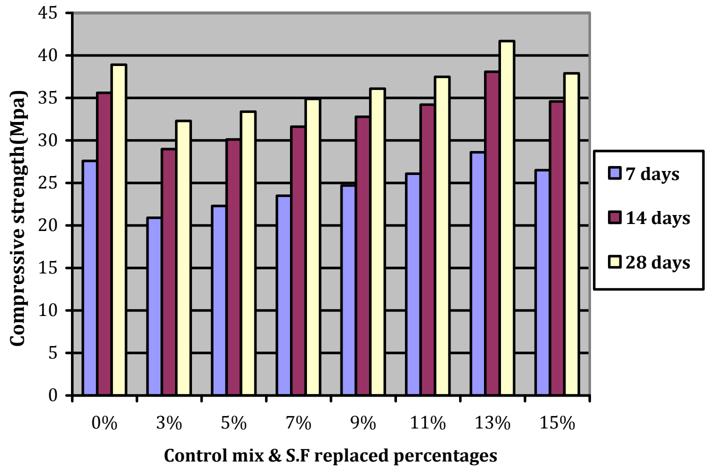


**Fig 1: Compressive strength test result comparison of coventional and replaced silica fume percentages**

Graph 1 shows that there is an increase in compressive strength with the increase in silica fume percentages upto 13% ,thereafter there is a decrease in compressive strength with further increase in silica fume in all the curing ages of concrete. The partial replacement 13% Silica fume is found to be suitable optimum. The results of compressive strength for M40 concrete is given in graph. The partial replacement of silica fume indicates 28% greater compressive strength as compared normal concrete.

### 2.Split tensile strength:

The test was carried out conforming to IS 516-1959 to obtain Split Tensile Strength of Concrete. The results of the splitting tensile strength tests conducted on concrete specimens of different mixes cured at different ages are presented and discussed in this section. The splitting tensile strength test was conducted at curing ages of 7, 14, 28 days. The cylinders were tested using Compression testing machine (CTM) of capacity 2000 KN.Variation of splitting tensile strength of all the mixes cured at 7, 14, and 28 days is also shown in graph.

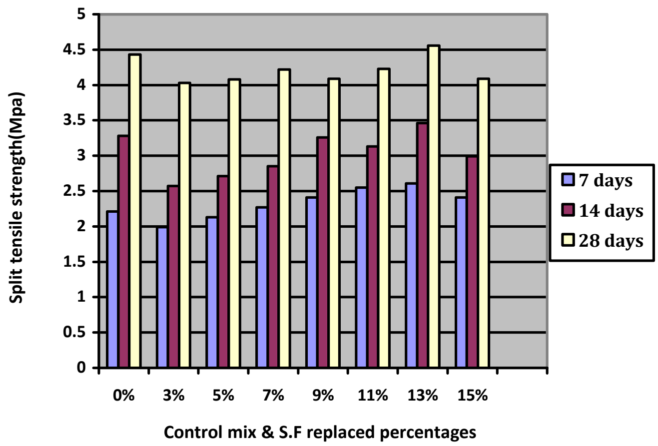


**Fig 2: Split tensile strength test result comparison of coventional and replaced silica fume percentages**

Graph 2 shows split tensile strength of concrete increases with the increase of percentage of silica fume as shown in above parameter. The partial replacement 13% Silica fume is found to be suitable optimum. The partial replacement of silica fume indicates 31% greater split tensile strength as compared normal concrete. The results of compressive strength for M40 concrete is given in above graph.

### 1. Flexural Strength:

The test was carried out conforming to IS 516-1959 to obtain Flexural Strength of Concrete strength at the age of 7, 14 and 28 days. In this study beam samples of size 100mm×100mm×500mm were cast and cured in water for 28 days. The beams were tested using Flexural Testing machine (FTM) of capacity 2000 KN. The results of the flexural strength tests conducted on concrete specimens of different mixes cured at different ages are presented and discussed in this section. Variation of splitting tensile strength of all the mixes cured at 7, 14, and 28 days is shown in graph 3.

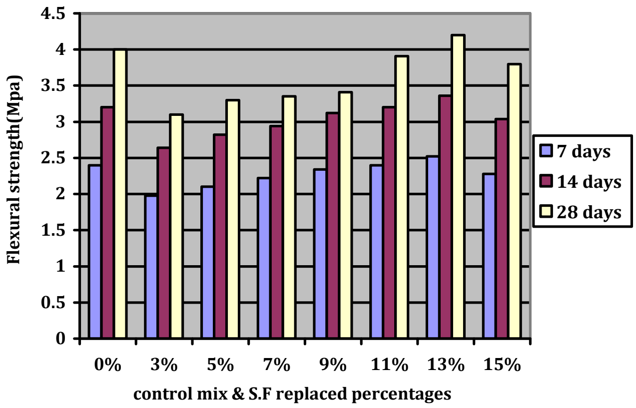


**Fig 3: Flexural strength test result comparison of coventional and replaced silica fume percentages**

Graph 3 shows flexural strength at the age of 7, 14, and 28 days silica fume concrete continuously increase with respect of controlled concrete and reached maximum value of 4.2 to 13 % replacement of silica fume. The partial replacement 13% Silica fume is found to be suitable optimum. The partial replacement of silica fume indicates 40% greater Flexural strength as compared to normal concrete. The results of compressive strength for M40 concrete is given in above graph.

### 4. Workability of Concrete Mixes:

The workability of concrete mixes was found out by slump test , compaction factor test , vee-bee test.

a. **Slump Test**: The test primarily measures the consistency of fresh concrete, hence detecting changes in the workability of concrete. It consists of a 300mm high frustum metal cone of internal diameter, 200mm at the base and 100mm at the top. The procedure was basically done by filling the frustum with fresh concrete in 3 layers of equal volume with each layer compacted with 25 strokes of a tamping rod. Thereafter, the frustum was removed and the concrete subsided. The slump or subsidence was measured as the difference between the top of the frustum and the subsided concrete according to BS 1881-102, EN 12350-2 (2000).

b. **Compacting factor Test** :This test measures the degree of compaction impacted on concrete for a standard workdone which is a reliable assessment of the workability of the concrete. The apparatus consists of upper and lower hoppers mounted on two sittings and a cylinder with a base sitting. The test was performed by placing the fresh concrete in the upper hopper A to its mouth with a hand trowel. The concrete was allowed to fall into the lower hopper B by opening the bottom trap door. Concretes stuck at the sides of the hopper A were pushed down into the lower hopper B with a steel rod. Again, the concrete in hopper B was allowed to fall into the cylinder beneath and weighed. The value recorded as W1. The cylinder was filled with fresh concrete in layers of 50mm compacted by 100%. The cylinder was wiped off, weighed and recorded as W2. The compaction factor was calculated as ratio (W1/W2) according to BS 1881: Part 103 (1993).

c. **Vee-bee test**: This test is suitable for a whole wide range of mixes and it is sensitive to variations in workability of very dry mixes and precast concrete mixes. The test measures the time taken to transform or remold a standard frustum of concrete by vibration to a compacted mass. Thus the time required to perform this action is the vee-bee time in seconds. The apparatus consists of a slump frustum placed at the center of a metal cylindrical container mounted on a vibrating table whose vibration is sinusoidal. A slump test as described above was conducted first, and then a clear plastic disc was placed on top of the fresh concrete. Then the vee-bee table is vibrated and the time taken for the remolding of the slump frustum shape to the shape of the metal cylindrical container was recorded as a measure of the consistency. The test is according to BS 1881-104, EN 12350-3 (2000).

The workability results of control mix and different percentage of S.F replaced concrete mixes are shown in table 8.

**Table 8 : Workability of Concrete Mixes**

| Mix | Slump(mm) | Compaction factor | Vee-bee time (sec) |
|---|---|---|---|
| 0% | 77 | 0.85 | 15 to 18 sec |
| 3% | 66 | 0.74 | 8 to 12 sec |
| 5% | 69 | 0.77 | 8 to 12 sec |
| 7% | 72.5 | 0.80 | 8 to 12 sec |
| 9% | 75 | 0.84 | 8 to 12 sec |
| 11% | 80.5 | 0.88 | 8 to 12 sec |
| 13% | 87 | 0.91 | 8 to 12 sec |
| 15% | 73 | 0.82 | 8 to 12 sec |

## V. CONCLUSION:

The following conclusion is made from the detailed experimental investigations conducted on the behaviour of normal grade concrete and replaced concrete. The compressive strength, split tensile strength, flexural strength has increased with increase in silica fume content, this increase is due to the pozzolanic action and binder formation of silica fume with cement. The decrease in strength beyond 13% silica fume may be due brittle behavior of concrete due to presence of extra binder. Compressive strength, Flexural strength, Split tensile strength of concrete Mixes made with and without silica fume has been determined at 7, 14, & 28 days of curing. The strength gained has been determined of silica fume added concrete with addition of 3%, 5%, 7%, 9%, 11% ,13%, 15% for M40 grade as a partial replacement of cement in conventional concrete. From the results it is conclude that the silica fume is a superior replacement of cement. The rate of strength increase in silica fume concrete is high. After performing all the tests and analysing their result, the following conclusions have been derived:

1. The compressive strength, split tensile strength, flexural strength of silica fume concrete is found to be more than normal concrete.

2. The results achieved from the existing study shows that silica fume is great potential for the utilization in concrete as replacement of cement.

3. Workability of concrete decreases as proportion of silica fumes increases than normal concrete.

4. Maximum compressive strength was observed when silica fume replacement is about 13% compared to normal concrete.

5. Maximum split tensile strength was observed when silica fume replacement is about 13% compared to normal concrete.

6. Maximum flexural strength was observed when silica fume replacement is about 13% compared to normal concrete.

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