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MECHANICAL PROPERTIES OF HIGH STRENGTH CONCRETE EFFECT OF STEEL FIBERS FLY ASH AND SILICA FUME

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ABSTRACT:
In last century, a lot of attempts were performed to upgrade and improve the mechanical behaviour of the concrete mix. By using several additions, concrete properties can be enhanced. In this study fly ash and silica fume are used as a replacement for cement along with steel fibers by volume of concrete. Here fly ash is replaced by 15%, 30% and silica fume is replaced by 6%, 12% and 18% for cement. Initially, a set of concrete specimens were casted with 15%, 30% fly ash and 6%, 12% and 18% silica fume with 0% addition of steel fibers and tested for compressive, flexural and split tensile strength. Secondly, another set of concrete specimens were casted with 15%, 30% fly ash and 6%, 12% and 18% silica fume with 0.5% addition of steel fibers and tested for the same. Similarly, another set of samples were casted 0%, 15%, 30% fly ash and 6%, 12% and 18% silica fume with 1% addition of steel fibers and tested to determine the mechanical properties of concrete. And it was observed that maximum compressive, flexural and split tensile strength was attained at 15% fly ash and 12% silica fume with 1% steel fiber.
Key words: HSC, NSC, SF,FA, SILICA FUME.

1.0 INTRODUCTION

High strength concretes (HSC) has been extensively used in construction industry in recent years since most of the rheological and mechanical characteristics of these materials are better than those of normal strength concretes (NSC). HSC contains chemical admixtures, for water reduction, and having a compressive strength between 50 and 80 MPa. Almost all these concretes have mineral additives involve for a variety of reasons including strength improvement, reduction of permeability, higher crack resistance and durability factors. Some pozzolans such as silica fume (SF) and fly ash (FA) have a significant potential in this context Advantageous incorporation of SF through pozzolanic reaction and micro-filler properties in HSC has been reported by some researchers Similarly, FA characteristic as a partial cement replacement has been investigated by different authors and it is concluded that in addition to many environmental benefits, it also improves the properties and quality of HSC. However, as strength and softness are inversely proportional, HSC is more brittle than NSC and has some poor performances in case of ductility. UE Due to the technical and architectural requirement, new types of concrete were developed. Most important developed

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type was high strength concrete because this kind of concrete provide higher compressive strength and allow to the designer to construct higher building with less slab thickness and smaller columns to give more aesthetic to these designs. By using of high strength concrete, the formwork can be removed in a little time with small amount of steel rebar in the high building which reduce the dead load. High strength concrete can be obtained by using the same material that used in normal strength concrete but with using additional techniques to get a material with long age and higher strength. Anyway, these days have a second revolution in concrete technology where the contradiction between high strength and low workability can be obtained by using the superplasticizers which allow to use a little amount of water. Some reduced water additives may reduce water by 0.25 of cement weight and at the same time give higher workability.

Objectives:

- To prepare the concrete cubes & beams using cement partly replaced by silica fume and fly ash
- To determine compressive strength of hardened concrete at 28 days of curing & compare various mixes.
- To determine flexural strength at 28 days of curing & compare various mixes

2.0 LITERATURE REVIEW

In recent years, demand has continued to grow for high strength concrete for use in infrastructure construction. This construction material is used in high-rise buildings to avoid the use of unacceptably oversized columns on lower floors, to allow large column spacing and more usable floor space, or to increase the overall height of the building without detracting from the aesthetics and function of the lower floors H. Katkhuda, B. Hanayneh and N. Shatarat [1]. They carried out by replacing cement with different percentages of silica fume at different constant water-binder ratio keeping other mix design variables constant. The silica fume was replaced by 0%, 5%, 10%, 15%, 20% and 25% for a water-binder ratios ranging from 0.26 to 0.42. For all mixes, split tensile, compressive and flexure strengths were determined at 28 days. Ting Lin, Ran Huang, [2]. They carried out to evaluate the mechanical properties of cement-based composites. Test variables included water to cementitious ratio, dosage of silica fume and volume fraction of steel fiber. Compressive strength test, direct tensile strength test, splitting tensile strength test, abrasion resistance test and drop weight test were performed and the results were analyzed statistically. According to the results of this study, the designed direct tensile testing method was a suitable method to estimate the tensile strength of fiber cement- based composites. K. Rejeb Khalid B. Najem [3]. They said the effect of steel fibers content and the combined effect of rice husk ash (RHA) and high range water reducing agent (HRWRA) on the mechanical properties of the produced matrix. The experimental results showed the using steel fibers in High-performance concrete led to a considerable improvement in mechanical properties of concrete. Pawade Prashant et al [4], they investigated on concrete due to the effect of silica fume with and without steel fibers on Portland Pozzolana cement. In this study we used concrete mixes with Silica Fume of 0%, 4%, 8%and 12% with addition of crimped steel fibers of two diameters 0.5 mm Ø and 1.0

mm Ø with a constant aspect ratio of 60, at various percentages as 0%, 0.5 %, 1.0 % and 1.5 % by the volume of concrete on M30 grade of concrete

Abhinav Shyam [5] concluded that optimum percentage of Silica Fume varies from 5% to 15%. Up to these Percentage Replacement improvement in the strength of concrete has been observed in terms of Compressive Strength, Flexural Strength and Tensile Strength on partial replacement of Cement with Silica fume. Anurag Jain [6] The effect of silica fume is more noticeable for the 28day curing period than for the 7-day period. On the other hand, the effect of curing period was not as significant for the control mix. Longer curing allows the Pozzolanic activity to develop, leading to the significant performance improvement. The variation in electric current was not consistent. A.M. Shende [7] Concluded that compressive strength, split tensile strength and flexural strength are on higher side for 3% fibres as compared to that produced from 0%, 1% and 2% fibres. All the strength properties are observed to be on higher side for aspect ratio of 50 as compared to those for aspect ratio 60 and 67. It is observed that compressive strength increases from 11 to 24% with addition of steel fibres, flexural strength increases from 12 to 49% with addition of steel fibres and split tensile strength increases from 3 to 41% with addition of steel fibres. Ali, B.; Qureshi, L.A.; Khan [8] carried out an experimental study on the performance of steel fiber reinforced concrete Cement concrete is the most extensively used construction material in the world. The reason for its extensive use is that it provides good workability and can be moulded to any shape. Khan, M.; Cao, M.; Xie [9] et al. carried out an experimental study on behavior of steel and glass fiber reinforced concrete composites fiber reinforced concrete (FRC) is a concrete in which small and discontinuous fibers are dispersed uniformly. The addition of these fibers into concrete mass can dramatically increase the compressive strength, tensile strength, flexural strength and impact strength of concrete. Liew, K.M.; Akbar et al. [10] carried out an experimental study on modulus of elasticity of steel fiber reinforced concrete plain, unreinforced concrete is a brittle material, with a low tensile strength, limited ductility and little resistance to cracking. In order to improve the inherent tensile strength of concrete there is a need of multidirectional and closely spaced reinforcement, which can be provided in the form of randomly distributed fibers. Steel fiber is one of the most commonly used fibers. Short, discrete steel fibers provide discontinuous three-dimensional reinforcement that picks up load and transfer stresses at micro-crack level

3.0 MATERIALS AND METHODS

General In this chapter various materials and method of conducting the test was discussed in detail and detailed methodology of the was presented. An Experimental study on the behavior of silica fume and steel fibre reinforced concrete has been conducted for various loading conditions. The results of the present investigation are compared with the other investigation.

Cement: Cement is an essential component in concrete which has the property of both adhesion and cohesion that helps other ingredients like fine aggregate, coarse aggregate and admixtures to form a uniform and compact paste. Presently, in this work ordinary Portland cement of grade 53 is used

Fine aggregate: The locally available sand is used as fine aggregate in the present investigation. The sand is free from clayey matter, salt and organic impurities. The sand is

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tested for various properties like specific gravity, bulk density etc., in accordance with IS 2386- 1963(28). Grain size distribution of sand shows that it is close to the zone 1 of IS 383-1970(29).

Table- 1 Properties of Fine Aggregate

S.N o	Property	Values
1	Specific gravity	2.68
2	Density	1640 kg/m³
3	Fineness Modulus	2.78

Coarse aggregate:

Coarse aggregates help in increasing the volume of the concrete, improves hardness and strength. Coarse aggregate considered is of angular crushed shape and 20 mm size aggregates are used in our work. As per IS 2386-1963 part 3, experiments were performed to determine the fineness modulus, specific gravity

Table- 2 Properties of coarse aggregate

S. No	Property	Values
1	Specific Gravity	2.64
2	Density	1700kg/m³
3	Fineness Modulus	7.14

Silica fume: Condensed Silica fume, also known as micro silica, is a dry amorphous powder which, when added with standard cements will increase the durability and strength of the concrete as well as reducing permeability and improving abrasion-erosion resistance. It may also be used in many applications where high strength is required.

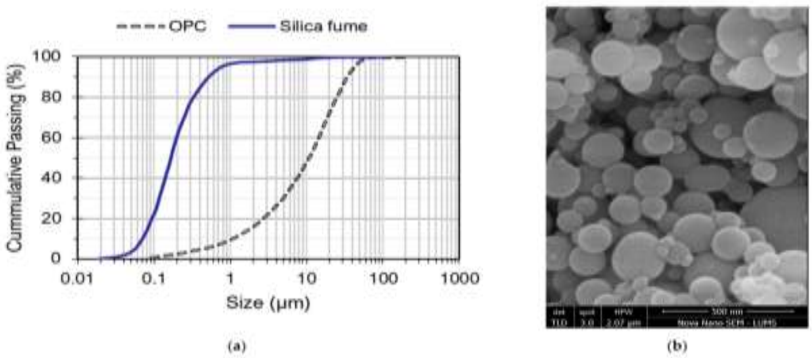

Figure: Particle size distribution: (a) granulometry of binder materials; (b) SEM observation of silica fume particles.

Table 3: Physical properties of silica fume

Specific gravity	2.25
Bulk density	570 kg/m³
Specific surface area	150000 cm²/g

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Steel fibres: Steel fibers are used to improve the flexural and tensile property of concrete, by volume of concrete. Here, steel fibers of diameter 0.5 mm and having length 60mm is used.

Table 4: Properties of steel fibers

Ultimate tensile strength	650 N/mm^2
Young's modulus	205 N/mm^2
Aspect ratio	120

Water: Potable water has been used in the experiment for mixing and curing

Super Plasticizer: The super plasticizer used in this experiment is SP430. It is manufactured by FOSROC. Super plasticizers are new class of generic materials which when added to the concrete causes increase in the workability. These consists mainly of naphthalene or melamine sulphonates, usually condensed in the presence of formaldehyde. Super plastised concrete is a conventional concrete containing a chemical admixture of super plasticizing agent. It enhances workability state to make reduction in water cement ratio of super plasticized concrete, while maintaining workability of concrete

MIX DESIGN OF M80 GRADE CONCRETE

Type of cement: OPC 53 grade

Maximum size of coarse aggregate: 20mm Exposure condition: moderate

Type of coarse aggregate: crushed angular shape Fine aggregate: Zone-I

Design mix target slump: 75 mm Specific gravity of cement: 2.98 Specific gravity of C.A: 2.64 Specific gravity of F.A: 2.78 Specific gravity of admixture: 1.1

Water absorption of coarse aggregate: 0.6% Water absorption of fine aggregate: 0.8% Assumed standard deviation: 5 N/mm^2

Target mean strength of concrete

fm= fck + 1.65S

= 80 + 1.65x5

= 88.25 N/mm^2

Calculation of cement content

water cement ratio = 0.31 and water content = 195 kg/m^3

Minimum cement content required= 195/0.31

= 629.03 kg/m^3

Design mix calculation

For 20mm size aggregates, w/c ratio of 0.31, slump of 75mm, percentage of fine aggregate= 38%

Density of fine aggregate = 1575.97*(38/100) = 598.86 kg/m^3

Density of coarse aggregate =1575.97-598.86= 977.28 kg/m^3

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(a) (b) (c)

Figure: Overview of splitting tensile failure: (a) plain HSC; (b) HSC with 1.5% Steel fiber; (c) crack bridging action of fibers

4.0 RESULTS & DISCUSSIONS

Compressive strength, flexural strength & split tensile strength tests were conducted for each set of concrete cubes, concrete beams and concrete cylinders respectively to analyze the mechanical behavior of concrete for fly ash replacing cement by 0%, 15% & 30% and silica fume by 0%, 6%, 12% & 18% with addition of steel fibers 0%, 0.5% & 1% after a curing period of 28 days.

Test Specimens

The test specimens for compressive strength test were made of cubes having a size of 150mm x 150mm x 150mm cast iron steel moulds were used. For each mix proportion three numbers of cubes were cast and tested at the age of 7 days and 28 days. The test specimens for split tensile strength test were made of cylinders having a size of100mm diameter and 300mm high cast iron moulds were used. For each mix proportion three numbers of cylinders were cast and tested at 28 days. The test specimens for Flexural strength test were made of prism having a size of 500mm x 100mm x 100mm cast iron steel moulds were used. For each mix proportion three numbers of prisms were cast and tested at the age of 28 days.

Table 5: shows the Details of test specimen.

S.No	Name Of Test	Size Of Specimen (Mm)	No. Of Specimen
1	Compressive Strength	150 x 150 x 150	36
2	Split tensile test	150 x 300	18
3	Flexural strength test	500 x 100 x 100	18
Total			72

COMPRESSIVE STRENGTH RESULTS

The cube specimen was tested for compressive strength at the end of 28 days. The specimen was tested after the surface gets dried. The load was applied on the smooth sides without shock and increased continuously till the specimen failed. The mean compressive strength is calculated and tabulated in Table

Table 6: Compressive strength values for various replacements of fly ash, silica fume with 0.5% steel fibers by volume of concrete for 28 days curing

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S.NO	Fly Ash (%)	Silica Fum (%)	Steel Fiber (%)	Compressive Strength (N/ Mm^2) 28 Days
1	0	0	0.5	77.58
2	0	6	0.5	78.72
3	0	12	0.5	79.60
4	0	18	0.5	79.53
5	15	0	0.5	78.51
6	15	6	0.5	79.57
7	15	12	0.5	**79.90**

Table 7: Compressive strength values for various replacements of fly ash, silica fume with 1% steel fibers by volume of concrete for 28 days curing

S.NO	FlyAsh (%)	Silica Fume (%)	SteelFiber (%)	Compressive Strength (N/ Mm^2) 28 Days
1	0	0	1	80.30
2	0	6	1	81.32
3	0	12	1	81.54
4	0	18	1	81.39
5	15	0	1	81.47
6	15	6	1	81.37
7	15	12	1	82.37

FLEXURAL STRENGTH RESULTS:

High flexural strength is essential for stress-bearing restorations, when high pressure/stress is exerted on the material or restoration. As a result, flexural strength also determines the indications for which a material can be used in this test observed table results

Table 8: Flexural strength values for various replacements of fly ash, silica fume with 0.5% steel fibers by volume of concrete for 28 days curing

S.NO	FlyAsh (%)	Silica Fume (%)	SteelFiber (%)	Flexural strength (N/Mm^2) 28 days
1	0	0	0.5	8.26
2	0	6	0.5	8.81
3	0	12	0.5	8.55
4	0	18	0.5	8.59
5	0	0	0.5	8.26
6	15	6	0.5	8.79
7	15	12	0.5	8.83

Table 9: Flexural strength values for various replacements of fly ash, silica fume with 1% steel fibers by volume of concrete for 28 days curing

S.NO	FlyAsh (%)	Silica Fume (%)	SteelFiber (%)	Flexural strength (N/Mm^2) 28 days
1	0	0	1	7.54

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2	0	6	1	7.83
3	0	12	1	8.13
4	0	18	1	8.04
5	15	0	1	7.74
6	15	6	1	8.03
7	15	12	1	8.97

SPLIT TENSILE STRENGTH RESULTS

Split tensile test is also referred as "Brazilian Test". Placing a cylindrical specimen horizontally between the loading surfaces of a compression-testing machine and the load is applied till the cylinder failed along the vertical diameter. The mean tensile strength is calculated and tabulate

Table 10: Split tensile strength values for various replacements of fly ash, silica fume with 0.5% steel fibers by volume of concrete for 28 days curing

S.NO	FlyAsh (%)	Silica Fume (%)	SteelFiber (%)	Spilt tensile strength (N/Mm^2) 28 days
1	0	0	0.5	7.24
2	0	6	0.5	7.55
3	0	12	0.5	7.52
4	0	18	0.5	7.64
5	15	0	0.5	7.72
6	15	6	0.5	7.74
7	15	12	0.5	7.86

Table 11: Split tensile strength values for various replacements of fly ash, silica fume with 1% steel fibers by volume of concrete for 28 days curing

S.NO	FlyAsh (%)	Silica Fume (%)	SteelFiber (%)	Spilt tensile strength (N/Mm^2) 28 days
1	0	0	1	6.53
2	0	6	1	6.82
3	0	12	1	7.13
4	0	18	1	7.05
5	15	0	1	6.63
6	15	6	1	7.38
7	15	12	1	7.95

CONCLUSION:

The following conclusions were drawn from the results obtained from the experiments:

1. It is observed that compressive strength for every concrete mix has failed to reach beyond target mean strength but compressive strength for every concrete mix having some percentage of fly ash, silica fume and steel fibers is higher than the compressive strength of control concrete specimen for 28 days curing.

2. It is examined that highest compressive strength of 79.90 N/mm^2 is attained for a mix of concrete having 15% fly ash and 12% silica fume with 1% steel fibers when compared to other concrete mixes.
3. It is noticed that flexural strength results for concrete mixes included with fly ash, silica fume and steel fibers are greater than the flexural strength obtained for ordinary concrete samples without fly ash, silica fume and steel fiber for 28 days curing.
4. Maximum flexural strength of 8.83 N/mm^2 is observed at a replacement of 15% fly ash and 12% silica fume with 1% steel fibers when compared to other concrete mixes.
5. It is further noticed that split tensile strength results for concrete mixes included with fly ash, silica fume and steel fibers are greater than the split tensile strength obtained for ordinary concrete samples without fly ash, silica fume and steel fiber for 28 days curing.
6. Highest split tensile strength of 7.95 N/mm^2 is observed at a replacement of 15% fly ash and 12% silica fume with 1% steel fibers when compared to other concrete mixes.

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