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EXPERIMENTAL STUDY ON MECHANICAL PROPERTITES OF HIGH STRENGTH CONCRETE USING SILICA FUME AND FIBERS (STEEL & POLYPROPYLENE FIBERS)

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ABSTRACT: Concrete is probably the most extensively used construction material in the world. The main ingredient in the conventional concrete is Portland cement. The amount of cement production emits approximately equal amount of carbon dioxide into the atmosphere. Cement production is consuming significant amount of natural resources. That has brought pressures to reduce cement consumption by the use of supplementary materials. Availability of mineral admixtures marked opening of a new era for designing concrete mix of higher and higher strength. Silica fume is a new mineral admixture, whose potential is not fully utilized. Moreover only limited studies have been carried out in India on the use of slag for the development of high strength concrete with addition of steel fibers. The study focuses on the flexural strength performance of the blended concrete containing 15% of silica fume and different percentages of steel and polypropylene fibers. The results shows that 15% replacement of cement with silica fume incorporation of 2% steel fibers better.

Key words: High strength concrete, silica fume, polypropylene fibers, steel fibers

1. INTRODUCTON

Concrete is a commonly used construction material. It traditionally consists of cement, fine aggregate, coarse aggregate and water. However modern concrete is produced by adding mineral and chemical admixtures also. IS 456-2000 suggested the use of fly ash, silica fume, ground granulated blast furnace slag (ggbfs), metakaoline, rice husk ash (RHA) in the production of concrete. Concrete has been categorized as ordinary, standard and high strength based on characteristic compressive strength at the age of 28 days. High strength concrete is being produced due to growing demand for taller and larger structures. As per IS 456, High strength concrete is a concrete with strength between 60 to 80 MPa. Such a concrete demands the use of supplementary cementitious materials (SCM) and super plasticizer in order to reduce cement consumption, increase strength, decrease permeability, and improve durability. It is noticed that high strength concrete is a relatively brittle material possessing lower tensile strength. Internal micro cracks are inherently present in the concrete and its poor tensile strength is due to the propagation of such micro cracks, eventually leading to brittle fracture of the concrete. It has been recognized that the addition of small, closely spaced and uniformly dispersed fibres in the concrete would act as crack arresters and would substantially improve its flexural strength. The toughness of HSFRC depends upon the percentage content of silica fume, fly ash, type of fibre, its volume fraction and aspect ratio. Such a concrete is in demand wherein resistance to cracking is a performance requirement of the structure e.g. liquid storage tanks.

2. Literature Review:

Various researchers have carried out experimental investigation to study the mechanical behaviour of high strength fibre reinforced concrete. The markable investigation carried out on mechanical properties of high strength fibre reinforced concrete (HSFRC) by P.S.Song and S. Hwang that the brittleness with low tensile strength and strain capacities of high strength concrete (HSC) can be reduce by the addition of steel fibres [1]. It is reported that the use of steel fibres in concrete decrease the workability of concrete but increase split tensile strength,flexural strength, modulus of elasticity and poisons ratio [3,4]. P.Balaguru and Mahendra Patel studied the flexural toughness of steel fibre reinforced concrete by using deformed and hooked end fibres. The results indicated that hooked end fibres provided better results than deformed fibre [5]. The experimental investigation is carried out to study the influence of fibre content on the compressive strength, modulus of rupture, toughness and splitting tensile strength [6,7,12]. S.P.Singh and S.K.Kaushik carried out an experimental program to study fatigue strength of steel fibre reinforced concrete (SFRC), in which they obtained the fatigue-lives of SFRC at various stress level and stress ratio. There results indicated that the

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statistical distribution of equivalent fatigue-life of SFRC is in agreement with the two-parameter Weibull distribution. The coefficient of the fatigue equation were determined corresponding to different survival probabilities so as to predict the flexural fatigue strength of SFRC for the desired level of survival probability [9]. The use of mineral admixtures such as silica fume and fly ash in high strength concrete gives the smaller paste porosity as compared to controlled concrete which increases the compressive strength, split tensile strength and flexural strength [10, 11, 13, 14, 17]. The production of good concrete can be done using automation and controlled environment but it not possible to alter its inherent brittle nature and the lack of any tensile strength. The addition of polypropylene fibres in plane concrete, it has increased the ductility and energy absorption capacity of concrete [18]. In the present investigation study is carried out on HSFRC by using various types of fibres.

3. MATERIALS AND PROPERTIES:

Various tests have conducted on the Raw materials to obtain the physical and mechanical properties. The detailed test results are given below.

Cement: OPC 53 of JPJ cement is used.

DETAILED PROPERTIES OF CEMENT:

Table : 1 test results of cement

TEST	Natural sand
Fineness of cement	97%
Normal consistency of cement	28% of water and initial distance 40mm and final distance 5mm
Specific gravity	3.16
Initial setting time	53min
Final setting time	222min

FINE AGGREGRATE: sand used for our investigation is collected form Godavari river sand which is conforming to Zone III as per Indian Specification 383-1970 codal provisions .

Table : 2 test results of fine aggregate

TEST	Natural sand
Sieve analysis	Zone II
Fineness modulus	2.60
Specific gravity	2.64
Water Absorption	0.9%
Bulk density	1656.0 Kg/m^3

COARSE AGGREGATE: The maximum size of coarse aggregate used in this process is 20 mm.

Table:3 test results of coarse aggregate

Property	Result
Specific gravity	2.80
Water absorption	0.1%
Fineness modulus	3.28
bulk density loosely loaded	1664.0 kg/m^3
Bulk density compacted	1717.0 kg/m^3

Silica fume

Table 4.determined physical properties of silica fume

Properties	Test values
Specific gravity	2.9
Specific area	20000m2/Kg
Bulk density	750-800 kg/m3
Particle shape	Irregular
diameter	NA

Steel fibers

Table 5: physical properties of steel fibers

Properties	Test values
Specific gravity	7.85
Bulk density	7850kg/m3
diameter	0.75mm
length	24mm
Modulus of elasticity	200GPa

Polypropylene fibers

Table 6: physical properties of PP fibers

Properties	Test values
Specific gravity	0.91
Bulk density	910kg/m3
diameter	0.075mm
length	18mm

4. MIX DESIGN:

The grade of concrete depends up on the mix design of the concrete. The mixes up to M20 are nominal

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mix, i.e. M5, M10, M15, M20. Whereas the mix above M20 is designed mix. The mix design is based in strength criteria and durability criteria used for moderate environment. The ratios by weight of cement, fine aggregate and coarse aggregate are obtained using the specifications given in 10262-2009 are given below. These proportions are maintained strictly same throughout the casting process to obtain a uniform standard and workable concrete mix. Normally Cubes were tested for compressive strength after 7and28 days curing. In this project the, 7,28days tests are conducted.

The process of considering required amount of ingredients of concrete and also calculating their relative amounts with the objective of producing a concrete of the required, strength, durability, and workability as economically as possible, is termed the concrete mix design. The proportioning of ingredients of concrete is governed by the required performance of concrete in two states, namely the plastic and the hardened states. If the plastic concrete is not workable, it cannot be properly placed and compacted. The property of workability, therefore, becomes of vital importance

The compressive strength of hardened concrete which is generally considered to be an index of its other properties, depending upon many factors, e.g. w/c ratio quality and quantity of cement, water, aggregate, exposure conditions, material properties, mixing, placing, compaction and soaked

In this project we consider the design specifications such as grade of concrete is M 50,exposure condition is severe, W/C as 0.4, slump of 100mm. required quantity of cement fine aggregate coarse aggregate is designed and final mix proportions is obtained. By considering the above design specifications and by considering the codal provisions in IS 10262-2009.

4.1 CONCRETE MIX DESIGN FOR M50 GRADE

1.Stipulation for proportioning:

Grade of concrete :M50
Type of cement;OPC 53
Maximum nominal size of aggregate=20
Minimum cement content =320kg/m3
Maximum water cement ratio:0.4
Workability=50mm slump
Degree of workability= good
Type of aggregate= crushed angular aggregate
Chemical admixture=no

2. test data:

cement used =OPC 53 Grade
Sepecfic gravity of fine aggragate=2.6
cement=3.15
Coarse aggrate=2.7
water absorption= coarse aggragte=0.5%
Fine aggragte=1%
Fine aggregate conforming – Zone-III as per (IS 383-table -2)

Mix Design for M60 Grade Concrete as per IS: 10262-2009 and IS: 456-2000

Step-1: target mean strength :

Fck^1=fc+(1.65*s)=60+(1.65*5)=58.25N/mm^2

Step-2: selection of water cement ratio

Referring table 5 of IS 456-2000, for very sever condition Maximum W/C ratio=0.4
In the present work Selected W/C ratio=0.4 0.4<0.45
Hence O K

Step 3:- Selection of Water content

From table 2 of IS 10262-2009

Maximum water content for 20mm aggregate= 186 liters (25-50mm slump) Calculated Water content for 50 mm slump = 186 litrs (According to clause 4.2 of IS: 10262-2009, for the desired workability other than 25 to 50 mm slump range, the required water content may be established by trail or an increase by about 3% for every additional 25mm slump)

Step 4:- Calculation of cement content

Water/cement ratio=0.4

Cement content=186/0.4=465kg/m^3

From table-5 of IS: 456-2000 minimum cement content for severe condition=320kg/m^3
465kg/m^3>320kg/m^3
Hence O.K

Step 5:- Proportion of volume of coarse aggregate and fine aggregate content

Referring IS:10262-2009,Table-3, Volume of coarse aggregate corresponding to 20mm size aggregate and fine aggregate (zone III) for W/C ratio of 0.5 is 0.64In the present case W/C ratio=0.38.Therefore, volume of coarse aggregate is required to be increased to decrease the fine aggregate Content. The proportion of volume of coarse aggregate is increased at the rate of +/- 0.01 for every -/+ 0.05 change in W/C ratio

Therefore the corrected proportion of volume of coarse aggregate for W/C of 0.4 = 0.66
Therefore, volume of coarse aggregate=0.66
Volume of fine aggregate=1-0.66=0.34

Step 6:-Mix Calculation

a) Concrete volume = 1m^3

b) Cement volume = cement weight / cement of specific gravity = [465.3/3.15]*[1/1000]

V_c = 0.147 m^3
c) Vol of water = weight of water content / specific gravity of water
= [186/1]*[1/1000]
V_W = 0.186 m^3
d) All aggregate in Vol = [a-(b+c)]
= [1-(0.147+0.186]
V_a = 0.667m^3
e) Mass of coarse aggregate = d*volume of CA*Specific gravity of coarse aggregate*1000
= [0.667 * 0.66 * 2.73 *1000]
$V_{ca=1188.59kg/m^3}$
f) Mass of fine aggregate = d*volume of FA*Specific gravity of fine aggregate*1000
= [0.667 * 0.34 * 2.65 * 1000]
V_{fa} = 589.6kg /m^3
Mix calculation for 1m^3
Cement=465.3kg/ m^3
Fine aggregate =589.6 kg/ m^3
Coarse aggregate=1188.59 kg/ m^3
Water=186
w/c=0.34
mix proportions: 465:589.6:1188.59
1:1.26:2.5

4.4 MIX PROPORTION:

- WEIGHT OF BEAM (100X100X500) = 14.2 Kgs
- As the ratio is 1:1.26:2.5,0.4
  1x + 1.26x + 2.5x + 0.45x = 14.2
  5.21x =14.2
  x = 2.7.2

Therefore Ratios of C: FA: CA: W in Kgsare2.72: 3.43: 6.8: 1.224
15 % of silica fume with respect to the weight of cement is 70gms
1% of STEEL FIBRES with respect to the weight of cement is 27.2gms
2% of STEEL FIBRES with respect to the weight of cement is 54.4gms
3% of STEEL FIBRES with respect to the weight of cement is 81.6 gms
1% of PP FIBRES with respect to the weight of cement is 27.2gms
2% of PP FIBRES with respect to the weight of cement is 54.4gms
3% of PP FIBRES with respect to the weight of cement is 81.6 gms

Mix Propotins

Mix designations	Cement content	Silica fume	PP fibers	Steel fiber	F.A content	C.A content	Water
M0	465	0	0	0	589	1188.5	186
M1	395	70	0	0	589	1188.5	186
M2	395	70	0	1 %	589	1188.5	186
M3	395	70	0	2 %	589	1188.5	186
M4	395	70	0	3 %	589	1188.5	186
M5	395	70	1%	0	589	1188.5	186
M6	395	70	2%	0	589	1188.5	186
M7	395	70	3%	0	589	1188.5	186

M 0: Mix for Conventional concrete
Mix 1 : 15% of Silica fume replacement with respect to the weight of cement
Mix 2 : 15% of Silica fume replacement with respect to the weight of cement an 1% SF
Mix 3 : 15% of Silica fume replacement with respect to the weight of cement an 2% SF
Mix 4 : 15% of Silica fume replacement with respect to the weight of cement an 3% SF
Mix 5 : 15% of Silica fume replacement with respect to the weight of cement an 1% PPF
Mix 6 : 15% of Silica fume replacement with respect to the weight of cement an 2% PPF
Mix 7: 15% of Silica fume replacement with respect to the weight of cement an 3% PPF

5. RESULTS AND DISCUSSIONS

Compressive strength results

The cubes of size 150*150mm is casted foe the mix design M50 and they are cured for 7 days ,28 days in normal curing then the cubes are tested by using the compression testing machine the results are shown below

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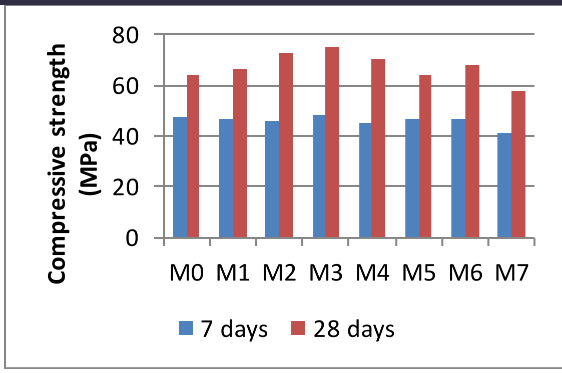

Figure 1 Compressive strength Results of concrete at various % s of fibers

In the above figure mix M3 give highest compressive strength at 7 days and 28 days curing. That means 2% steel fibers added concrete give good strength. Because fiber content is more in concrete it produce air space and reducing binding content.

Split Tensile strength

The cylinders of size 150mm diameter 300 mm length is casted foe the mix design M60 and they are cured for 7 days ,28 days in normal curing then the cylinders are tested by using the compression testing machine the results are shown below

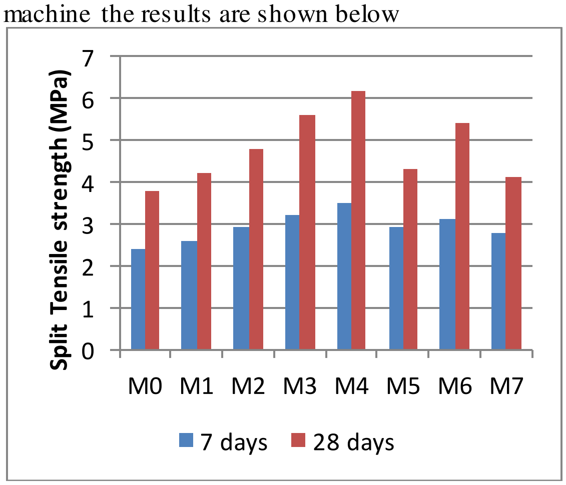

Figure 2 Split tensile strength Results of concrete at various % s of fibers

In figure 2 Split tensile strength of cocncrete of different mix designation based on the %replacement of silica fume & steel fibers and silica fume & PP fibers. Mix M 3 means 15% silica fume and 2% steel fibers added concrete has the high split tensile strength at 7 days and 28 days normal curing.

Flexural strength

The beams are casted for the mix design M60 and they are cured for 7 days ,28 days in normal curing then the beams are tested by using the compression testing machine the results are shown below

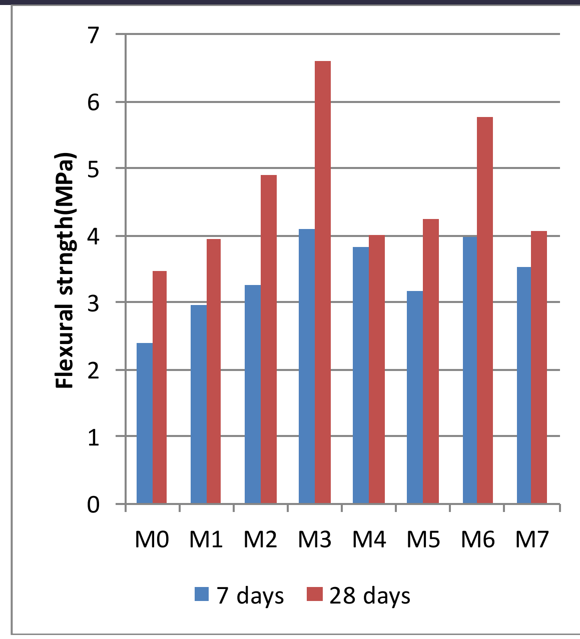

Figure3 Flexural strength Results of concrete at various % s of fibers

In figure 3 flexural strength of the concrete of different mix designation based on the %replacement of silica fume & steel fibers and silica fume & PP fibers. Mix M 3 means 15% silica fume and 2% steel fibers added concrete has the high split tensile strength at 7 days and 28 days normal curing.

CONCLUSION

- The Flexural strength of concrete where Silica fume is added as admixture with partial replacement of cement has shown increase in Flexural strength as the amount of admixture is increased when compared to a control mix
- The flexural strength of concrete goes on increasing with the increase in fibre content up to the optimum value. The optimum value for flexural strength of steel fibre reinforced cement concrete was found to be 2 %.
- The flexural strength of concrete goes on with the increase in fibre content up to the optimum value. The optimum value for flexural strength of polypropylene fibre reinforced cement concrete was found to be 2 %.
- The percentage increase in the Flexural strength of admixture mixed concrete(Silica fume 15%) and 2% steel fibre with the control mix for 7 days and 28 days is 41.18% and 47.5% respectively. In case of PP fibers the flexural strengthvale is increased 23.18% and 24.9%
- The compressive strength of concrete with 15% replacement silica fume give highest strength

than control mix.

- The Compressive strength of concrete goes on increasing with the increase in fibre content up to the optimum value. The optimum value for flexural strength of steel fibre reinforced cement concrete was found to be 2 %.
- The split tensile strength of concrete with 15% replacement silica fume give highest strength than control mix.
- The split tensile strength of concrete goes on increasing with the increase in fibre content up to the optimum value. The optimum value for flexural strength of steel fibre reinforced cement concrete was found to be 2 %.
- The split tensile strength of concrete goes on increasing with the increase in fibre content up to the optimum value. The optimum value for flexural strength of PP fibre reinforced cement concrete was found to be 2 %.

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