An Experimental Study on Strength and Durability for Polypropylene Fibre Reinforced Concrete with Partial Replacement of Cement by Silica Fume

R.Ambika
Assistant Professor, Department of Civil Engineering, Thamirabharani Engineering College, Thatchanallur, Tirunelveli – 627358, Tamil Nadu, India.

S.Petchiammal
Assistant Professor, Department of Civil Engineering, Thamirabharani Engineering College, Thatchanallur, Tirunelveli – 627358, Tamil Nadu, India.

ABSTRACT - Recent earthquakes in various part of the world points out the importance of seismic analysis. BIS code IS 1893 (part 1):2002 recommend dynamic analysis for the seismic analysis of buildings. Whether the code provisions are adequate for the earthquake resistant design of structures is the topic of interest for this thesis work. IS 1893 was revised in 2002 and following are the major and important modifications made in this revision:

a) **The seismic zone map is revised with only four zones, instead of five. Zone I has been merged to Zone II. Hence, Zone I does not appear in the new zoning; only Zones II,III, IV and V do.**

b) **The values of seismic zone factors have been changed.**

c) **Response spectra are now specified for three types of founding strata, namely rock and hard soil, medium soil and soft soil.**

d) **Modal combination rule in dynamic analysis of buildings has been revised.**

Strong ground motion from a nearby source has frequency content in the same range as the natural frequencies of buildings. This may have serious repercussions and is the topic of this thesis. Buildings are designed as per building code standards. Strong motion from large earthquakes has been recorded only in recent times. The buildings, especially irregular in nature, designed as per the latest code regulations perform if they were to be shaken with an intensity, frequency content and duration similar to a strong ground motion. Further non linear effects and higher mode contributions plays an important role in the seismic analysis of irregular buildings. Non linear time history analysis yields the true response of the structures. Practical difficulties for using non linear time history analysis leads to the use of a non linear static pushover analysis for the seismic analysis of structures.

Keywords—: **Water Cement Ratio, Aggregates, Light Weight, Economical, Compressive Strength, Cube, Cylinder.**

I. INTRODUCTION

Fibre reinforced concrete (FRC) is concrete containing fibrous material which increases its structural integrity. It contains short discrete fibers that are uniformly distributed and randomly oriented. Fibers include steel fibers, glass fibers, synthetic fibers and natural fibers. Fibres are usually used in concrete to control cracking due to both plastic shrinkage and drying shrinkage. They also reduce the permeability of concrete and thus reduce bleeding of water. Some types of fibers produce greater impact, abrasion and shatter resistance in concrete. Generally fibers do not increase the flexural strength of concrete, and so cannot replace moment resisting or structural steel reinforcement. Indeed, some fibers actually reduce the strength of concrete.

The amount of fibres added to a concrete mix is expressed as a percentage of the total volume of the composite (concrete and fibers), termed volume fraction (V_f). V_f typically ranges from 0.1 to 3%. Aspect ratio (l/d) is calculated by dividing fiber length (l) by its diameter (d). Fibres with a non-circular cross section use an equivalent diameter for the calculation of aspect ratio. If the modulus of elasticity of the fibre is higher than the matrix (concrete or mortar binder), they help to carry the load by increasing the tensile strength of the material. Increase in the aspect ratio of the fibre usually segments the flexural strength and toughness of the matrix. However, fibres which are too long tend to "ball" in the mix and create workability problems.

A. MINERAL ADMIXTURES IN CONCRETE
Mineral admixture is a material other than water, aggregate, cement, used as an ingredient of concrete or mortar added to the batch immediately before or during mixing. A proper use of admixtures offers certain beneficial effects to concrete, including improved quality, acceleration or retardation of setting time, enhanced frost and sulfate resistance, control of strength development, improved workability, and enhanced finish ability. According to a survey by the National Ready Mix Concrete Association, 39% of all ready-mixed concrete producers use fly ash, and at least 70% of produced concrete contains a water-reducer admixture. Admixtures vary widely in chemical composition, and many perform more than one function. Two basic types of admixtures are available: chemical and mineral. All admixtures to be used in concrete construction should meet specifications; tests should be made to evaluate how the admixture will affect the properties of the concrete to be made with the specified job materials, under the anticipated ambient conditions, and by the anticipated construction procedures. Mineral admixtures (fly ash, silica fume [SF], and slags) are usually added to concrete in larger amounts to enhance the workability of fresh concrete; to improve resistance of concrete to thermal cracking, alkali-aggregate expansion, and sulfate attack; and to enable a reduction in cement content.

B. SCOPE AND OBJECTIVE OF THE STUDY
The main objective of the present work is to develop concrete with good strength and enhanced durability. In order to achieve this use of pozzolanic material like silica fume and fibre is required.

- To produce concrete with enhanced durability and thereby reducing maintenance and repair cost by the incorporation of fibres and mineral admixture like silica fume.
- To minimize the demand of cement by replacing cement with mineral admixture like silica fume.
- To utilize the waste and locally available material ie. Silica fume in a useful manner.

C. METHODOLOGY
- Tested the material properties as per IS code procedures.
- Mix design for concrete proportion was arrived at as per IS- 10262- 1982.
- The properties of fresh concrete were determined as per IS- 1199- 1959.
- The concrete specimens were casted and cured as per IS procedures.
- Tests were conducted on hardened concrete to determine various strength parameters.
- Various durability tests were conducted as per standard codes.
- Finally results were compared with conventional concrete and partial replacement concrete mixed with fibre and conclusions were arrived at.

II MATERIALS USED AND THEIR PROPERTIES

A. SILICA FUME
Silica fume also referred as microsilica or condensed silica fume is another material that is used as an artificial pozzolanic admixture. It is extremely fine with particle size less than 1 micron and with an average diameter of about 0.1 micron, about 100 times smaller than average cement particles. Silica fume has specific surface area of about 20,000m^2/kg, as against 230 to 300 m^2/kg.

B. SUPER PLASTICIZER
Superplasticizers or chemical admixtures are added to concrete mix to improve workability and reduce water content. These can be added to concrete mix having a low to-normal slump and water cement ratio to produce high slump flowing concrete.

C. CEMENT
In the present work 53 grade cement was used for casting cubes and cylinders. The cement was uniform color i.e. grey with a light greenish shade and was free from any hard lumps.

D. AGGREGATES

Fine aggregates

Fine aggregate material passing through an IS sieve that is less than 4.75mm gauge. Usually natural sand is used as a fine aggregate at places where natural sand is not available crushed stone is used as a fine aggregate. The sand used for the experimental works was locally procured and conformed to grading zone III.

Coarse aggregates

The materials which are retained on a 4.75mm sieve are called coarse aggregate. Coarse aggregate forms the main matrix of the concrete. The nature of work decides the maximum size of the coarse aggregate. Locally available coarse aggregate having the maximum size of 20 mm was used in the present work.

E. WATER

Potable water is generally considered satisfactory. In the present investigation, tap water was used for both mixing and curing purposes.

F. POLYPROPYLENE FIBRES

Polypropylene fibre contents of up to 12% by volume are claimed to have been used successfully with hand-packing fabrication techniques, but volumes of 0,1% of 50-mm fibre in concrete have been reported to have caused a slump loss of 75 mm. Polypropylene fibres have been reported to reduce unrestrained plastic and drying shrinkage of concrete at fibre contents of 0.1 to 0.3% by volume. Polypropylene fibres the most popular of the synthetics are chemically inert, hydrophobic, and lightweight. They are produced as continuous cylindrical monofilaments that can be chopped to specified lengths or cut as films and tapes and formed into fine fibrils of rectangular cross section. Used at a rate of at least 0.1 percent by volume of concrete, polypropylene fibres reduce plastic shrinkage cracking and subsidence cracking over steel reinforcement. The presence of polypropylene fibres in concrete may reduce settlement of aggregate particles, thus reducing capillary bleed channels. Polypropylene fibres can help reduce spalling of high strength, low-permeability concrete exposed to fire in a moist condition.

New developments show that monofilament fibres are able to fibrillate during mixing if produced with both, polypropylene and polyethylene resins. The two polymers are incompatible and tend to separate when manipulated. Therefore, during the mixing process each fiber turns into a unit with several fibrils at its end. The fibrils provide better mechanical bonding than conventional monofilaments. The high number of fine fibrils also reduces plastic shrinkage cracking and may increase the ductility and toughness of the concrete. Improve mix cohesion, improving pumpability over long distances.

III MATERIAL PROPERTIES

A. Silica Fume

Silica fume used was confirming to ASTM- (1240-2000) and was supplied by “ELKEM INDUSTRIES”.

Table: 1 Chemical and Physical Properties of silica fume

Components	Value
Chemical Properties	%
SiO_2	90 – 96
Al_2O_3	0.5 – 0.8
MgO	0.2 – 1.5
Fe_2O_3	0.2 – 0.8
CaO	0.1 – 0.5
Na_2O	0.2 – 0.7
K_2O	0.4 – 1.0
C	0.5 – 1.4
S	0.1 – 0.4
Loss of Ignition	0.7 – 2.5
Physical Properties	
Specific gravity	2.2
Surface area (m^2/Kg)	20,000
Size (Micron)	0.1

Bulk Density (Kg/m^3)	576

B. Super Plasticizer

In this investigation super plasticizer- CONPLAST-SP 430 was used. It confirms to IS: 9103-1999. The properties of super plasticizer are shown below:

Table: 2 Properties of superplasticizer

Specific Gravity	1.220 – 1.225
Chloride content	NIL
Air entrainment	approximately 1% additional air is entrained

C. Cement

Ordinary Portland Cement of Ultratech brand of 53 grade confirming to IS: 12269-1987 was used in the present study. The properties of cement are shown below:

Table: 3 Physical properties of cement

Properties	Values
Specific gravity	3.1
Normal consistency	32%
Initial setting	45 mins
Fineness	5%

D. Fine Aggregate

Natural sand as per IS: 383-1987 was used. The properties are:

Table: 4 Physical properties of fine aggregates

Characteristics	Value
Type	Natural sand
Specific gravity	2.57
Fineness modulus	2.28
Grading zone	II

E. Coarse Aggregate

Crushed aggregate confirming to IS: 383-1987 was used.

Table: 5 Properties of coarse aggregates

Characteristics	Value
Type	Crushed
Specific gravity	2.74
Maximum size	20mm

F. Fibre

Polypropylene fibre (CTP 2024) is a type of fibre developed after vast research in the area. Polypropylene fibres of 6mm, 12mm, 18mm, and 24mm are available. Fibres of length 12mm and aspect ratio 340 was used for the experimental work here.

Table: 6 Specifications of the fibre

Cross section	Triangular
Fibre length	12mm
Dispersion	Excellent
Specific gravity	0.91
Color	Brilliant white
Melt point	160°c
Filament diameter	(25- 45) microns
Alkali resistance	Very good

U V stability	Good – very good
Electrical conductivity	Low

G. MIX DESIGN

Table 7 Mix proportion for M35

Water	**Cement**	**Fine aggregate**	**Coarse aggregate**
185.4 Kg/m^3	515 Kg/m^3	463.5 Kg/m^3	1501.33 Kg/m^3
0.36	1	0.9	2.92

H. OUTLINE OF THE PRESENT WORK

In the present investigation an effort was made to study the influence of polypropylene fibres and silica fume on strength and durability parameters of concrete. Cement was replaced partially with silica fume which has proved to be an efficient mineral admixture due to its pozzolanic action and fineness which enables good particle packing. Polypropylene fibre which is a synthetic fibre is used for the production of fibre reinforced concrete. At first, fibres were added in varying percentages (0.2%, 0.4%, 0.6%, 0.8%) to the weight of cement and cubes, cylinders and prisms of size 150mmx150mmx150mm, 150 mm diameter and 300 mm height and 750mmx 750mm x 150mm were casted. And these specimens were tested for compression, split tensile strength and flexural strength. The percentage of fibre which gave maximum strength values was taken as the optimum dosage of fibre and this percentage was used for the further study. Thus optimum dosage of fibre was obtained as 0.6%. Cement was replaced with silica fume by 5%.

M1 OPC
M2 OPC+5% Silica Fume
M3 OPC+0.6% Polypropylene Fibre
M4 OPC+5% Silica Fume+0.6% Polypropylene Fibre

Cubes, cylinders and prisms were casted and testes for 7 and 28 days strength with 0.6% addition of polypropylene fibres and 5% replacement of silica fume. Superplasticizer was added for better workability and optimum dosage of superplasticizer was determined using marsh cone test. Thus various strength parameters were studied. Apart from this certain durability tests were also performed. Various tests conducted are discussed below.

IV TESTS RESULTS AND DISCUSSIONS

A. TESTS ON CEMENT

Table: 8 Effect of Silica Fume on consistency of cement:

% of cement replaced by Silica Fume	Consistency (%)
0	32
5	36

Table: 9 Effect of Silica Fume on compressive strength of cement:

Percentage of cement replaced by Silica Fume	3 Days strength (Mpa)	7 Days strength (Mpa)
0	16.83	22.5
5	20.33	28.38

From the tests results obtained it shows that there is an increase in the consistency of cement with the replacement of silica fume by 5%. Studies have proved that consistency increases with increase in percentage of silica fume. Silica fume has influence on compressive strength of cement mortar. The strength values at 3 and 7 days are found to be increased. But the increase in strength is not very much significant.

B. TESTS ON FRESH CONCRETE

Marsh Cone Test:

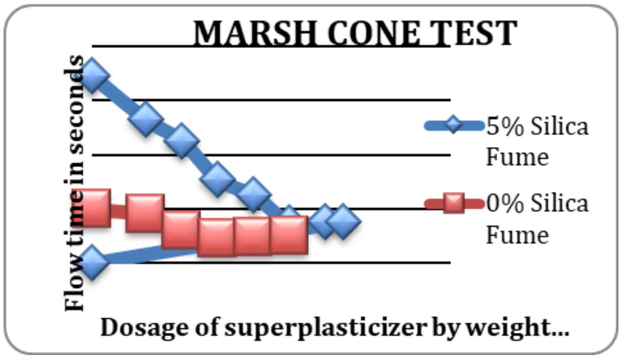

Fig: 1 Marsh cone time of cement paste with and without silica fume Vs dosages of superplasticizer in M35 grade concrete**.**

Table: 10 Effect on slump and compaction factor:

Parameters	Slump (mm)	Compaction Factor
0% of Silica Fume	102	0.9
5% of Silica Fume	45	0.88
5% of Silica Fume + SP	106	0.91

The percentage of superplasticizer to be added was determined from the marsh cone test. By analyzing the flow time the percentage was fixed to be 0.65%. Silica fume also has influenced the slump and compaction factor value. Superplasticizer was added to obtain required workability.

C. TESTS ON HARDENED CONCRETE

Test results for Optimum dosage of fibres.

Table: 11 Optimum Dosage of polypropylene fibre:

Fibre (%)	Compressive Strength (N/mm^2)	Split Tensile strength (N/mm^2)	Flexural Strength (N/mm^2)
0.2	25.77	1.71	3.37
0.4	26.66	1.82	4.24
0.6	29.23	2.65	4.43
0.8	29.75	1.78	3.56

Compressive strength results:

Table: 12 Compressive strength of cubes:

Parameters	7 Days strength(MPa)	28 Days strength(MPa)
OPC	25.21	36.30
OPC+SILICA FUME	29.38	42.37
OPC+PP FIBRE	27.50	38.46
OPC+SF+PP FIBRE	30.95	40.29

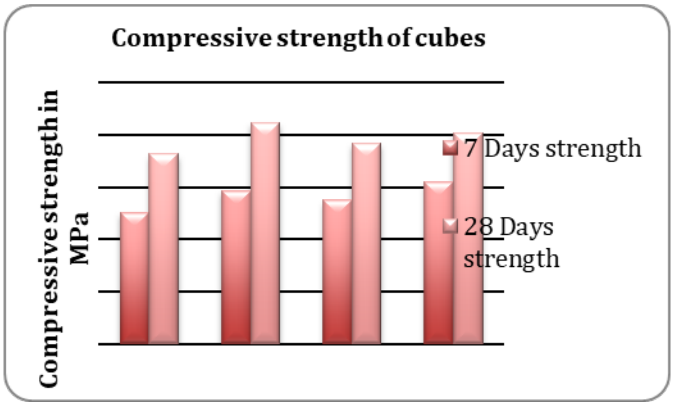

Fig: 2 Effect on Compressive strength of cubes

Split Tensile Strength results:
Table: 13 Split tensile Strength:

Parameters	7 Days strength(MPa)	28 Days strength(MPa)
OPC	3.11	4.12
OPC+SILICA FUME	3.56	4.67
OPC+PP FIBRE	3.98	5.23
OPC+SF+PP FIBRE	3.87	4.735

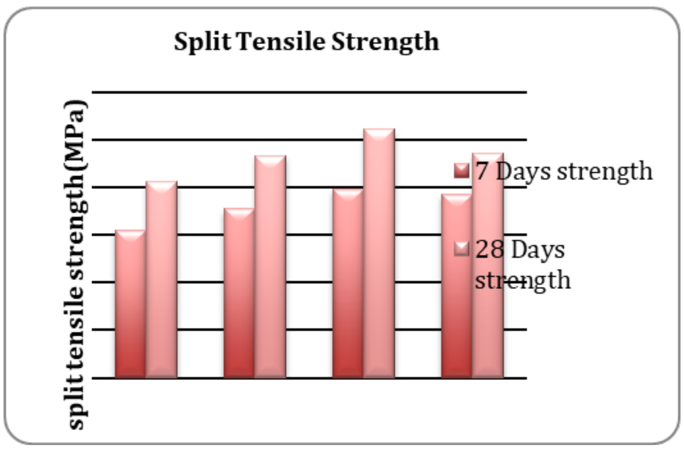

Fig: 3 Effect on Split tensile strength of concrete

Flexural Strength results:
Table: 14 Flexural Strength

Parameters	7 Days strength (MPa)	28 Days strength (MPa)
OPC	3.89	5.84
OPC+SILICA FUME	4.04	6.01
OPC+PP FIBRE	4.83	7.75
OPC+SF+PP FIBRE	4.53	6.99

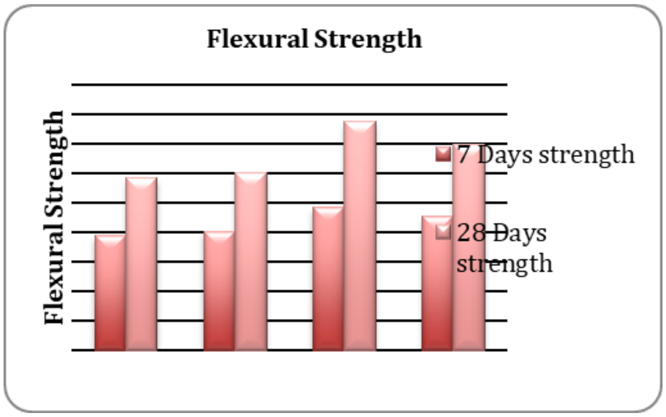

Fig: 4 Effect on Flexural Strength of concrete

Compressive strength of cubes and cylinders

Table: 15 Comparison of Compressive strength of cubes and cylinders at 60 days

Parameters	Compressive strength of cubes at 60 days	Compressive strength of cylinders at 60 days
OPC	40.37	36.725
OPC+SILICA FUME	57.44	49.78
OPC+PP FIBRE	49.84	40.98
OPC+SF+PP FIBRE	54.43	46.13

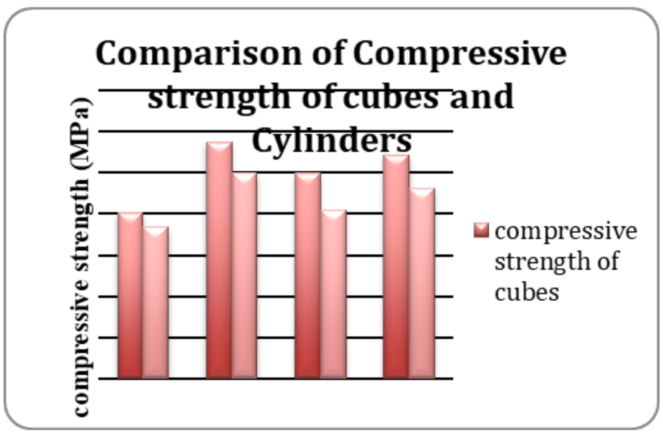

Fig: 5 Comparison of compressive strength of cubes and cylinders

Modulus of Elasticity values:

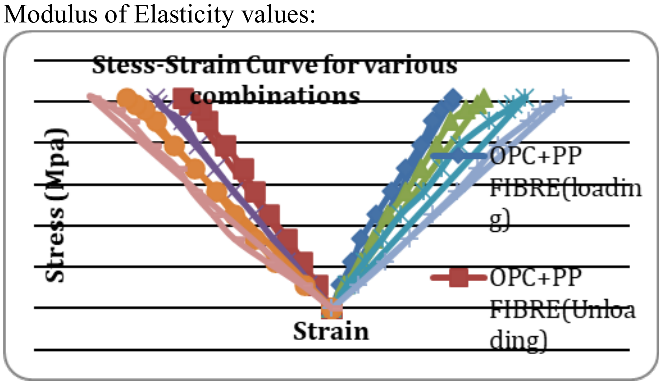

Fig: 6 Stress-Strain Curve (Loading Unloading) for various combinations

Table:16 Modulus of elasticity

Parameters	Modulus Of Elasticity(GPa)
OPC	23.24
OPC+SILICA FUME	25.38
OPC+PP FIBRE	31.75
OPC+SF+PP FIBRE	28.59

Poisson's Ratio values:

Table: 17 Poisson's Ratio:

Parameters	Poisson's ratio
OPC	0.114
OPC+SILICA FUME	0.199
OPC+PP FIBRE	0.169
OPC+SF+PP FIBRE	0.242

Table: 18 Density of Cubes and Cylinders:

Parameters	Density of cubes at 60 Days(Kg/m^3)	Density of Cylinders at 60 days(Kg/m^3)
OPC	2522.37	2380.709
OPC+SILICA FUME	2551.703	2402.42
OPC+PP FIBRE	2533.33	2393.353
OPC+SF+PP FIBRE	2413.629	2306.15

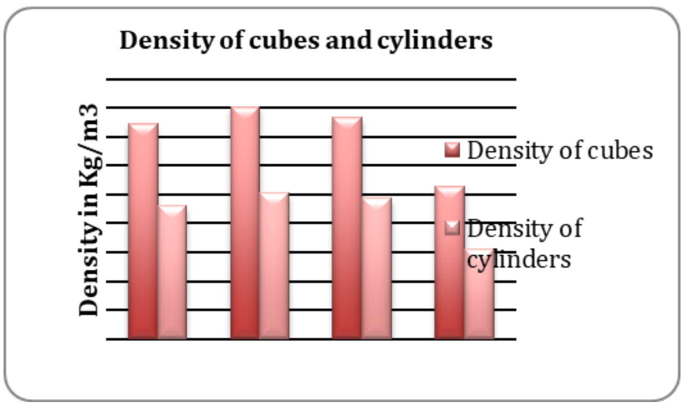

Fig: 7 Comparison of density of cubes and cylinders

The partial replacement of cement by silica fume and addition of polypropylene fibres into concrete is found to have positive impacts. The combination with both silica fume and fibre found to have maximum compressive strength. Where as in case of flexural and split tensile strength the combination with polypropylene fibre gives maximum results followed by other combinations. In every combination an enhancement in strength is observed compared to the conventional concrete. Compressive strength of cubes and cylinders almost has same pattern values except that compressive strength of cubes is higher than that of cylinders. These combinations also have effect on modulus of elasticity and poisons ratio of concrete. The fibre only mix has maximum modulus of elasticity whereas the mix with polypropylene fibre and silica fume gave highest poisons ratio.

C. DURABILITY TESTS

Acid Resistance test results:

Table: 19 Effect of acid attack on weight and compressive strength of cubes

Parameters	Loss in Weight (%) At 30 Days	Loss in Compressive strength (%) At 30 Days
OPC	4.4	11.91
OPC+SILICA FUME	2.81	8.18

OPC+PP FIBRE	4.14	9.78
OPC+SF+PP FIBRE	1.93	6.44

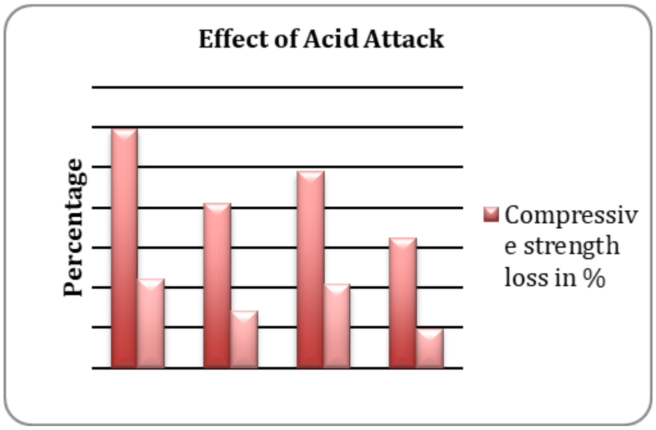

Fig: 8 Effect of acid attack on weight and compressive strength of cubes

Sulphate Attack test results:

Table: 20 Effect of sulphate attack on weight and compressive strength of cubes

Parameters	Loss in Weight (%) At 30 Days	Loss in Compressive strength (%) At 30 Days
OPC	4.14	7.87
OPC+SILICA FUME	2.11	4.98
OPC+PP FIBRE	2.46	6.10
OPC+SF+PP FIBRE	1.68	5.45

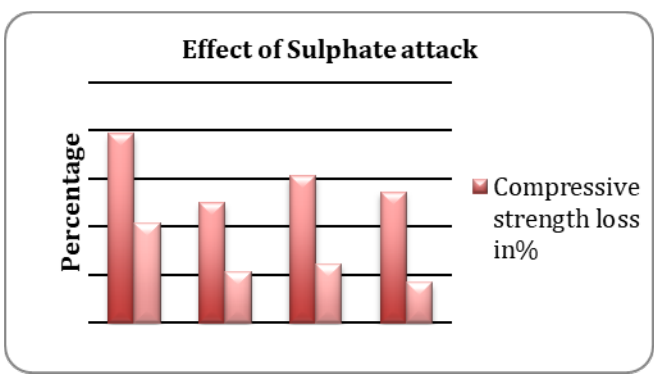

Fig: 9 Effect of sulphate attack on weight and compressive strength of cubes

Water absorption and porosity:

Table: 21 Water absorption and porosity values

Parameters	Saturated water absorption at 60 days (%)	Porosity at 60 days (%)
OPC	2.16	3.24
OPC+SILICA FUME	1.89	2.56
OPC+PP FIBRE	2.93	4.34

OPC+SF+PP FIBRE	1.927	2.15

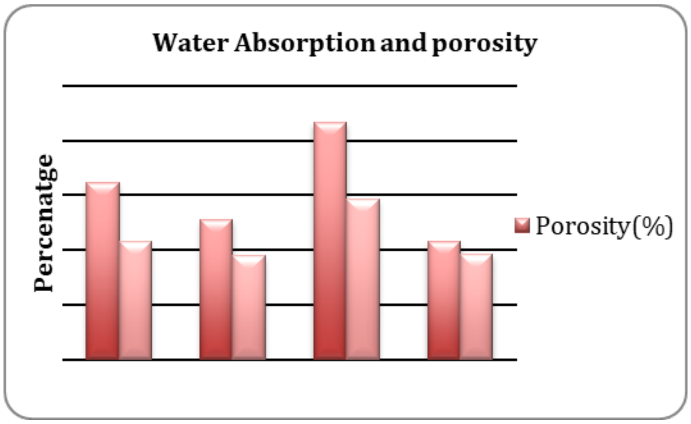

Fig:10 Effect of silica fume and fibre on water absorption and porosity

Initial surface absorption test:

Table: 22 Water permeability due to initial surface absorption test

Parameters	Average rate of penetration of water at 60 days (ml)
OPC	16.5
OPC+SILICA FUME	9.6
OPC+PP FIBRE	14.8
OPC+SF+PP FIBRE	11.2

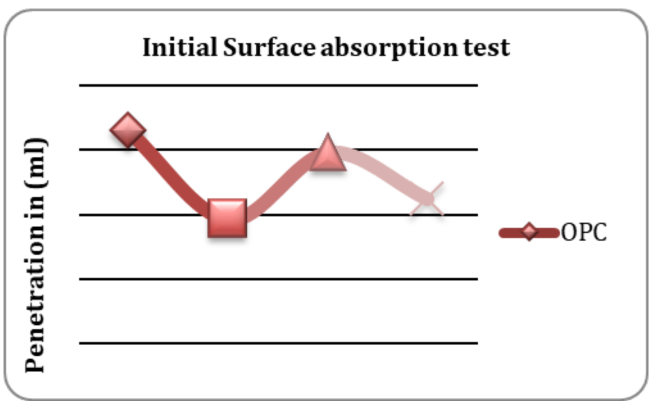

Fig: 11Water permeability due to initial surface absorption test

Thermoshock:

Table: 23 Compressive strength of concrete cubes before and after thermoshock

Parameters	Compressive strength at 60 days in (MPa)			
	Without thermo shock	Temperature in °C		
		100° C	200° C	300° C
OPC	41.38	37.33	34.28	32.62
OPC+SILICA FUME	57.92	52.88	48.66	39.77
OPC+PP FIBRE	51.25	48.44	46.67	37.33
OPC+SF+PP	55.38	53.33	50.82	46.44

FIBRE				

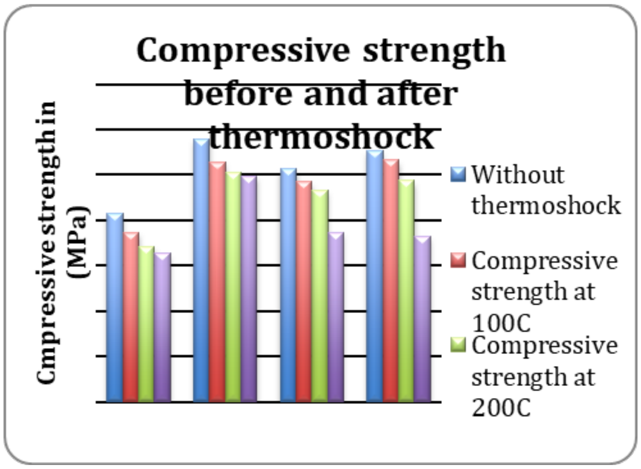

Fig: 12 Compressive strength of cubes after thermoshock

The action of acids on concrete is the conversion of calcium compounds into calcium salts of the attacking acid. These reactions destroy the concrete structure. The mix with fibre and silica fume shows maximum durability to acid and sulphate attack. Saturated water absorption and porosity is the measure of volume of pores in hardened concrete. Saturated water absorption and porosity is minimum in combination with both fibre and silica fume. Hence it is found to have better durability compared to other combinations. In case of initial surface absorption test the mix with silica fume only showed least water permeability. The combination with fibre and silica fume obtained highest compressive strength values at higher temperatures proving to have enhanced durability under thermoshock.

V CONCLUSIONS

Extensive experimentation was carried out to study the effects of silica fume and fibres in strength and durability of concrete and the following conclusions were arrived at from the present investigation.

1) Consistency of cement depends upon its fineness. Silica fume is having greater fineness and surface area compared to cement so the consistency increases greatly, when silica fume is added.

- It was observed that normal consistency increases about 12.5% when cement was replaced with 5% of silica fume.

2) The results of the present investigation indicate that other mix design parameters remaining constant, silica fume and polypropylene incorporation in concrete results in significant improvements in the strength parameters and durability of concrete. From tests conducted on hardened concrete following conclusions were made.

- Compressive strength is found to be maximum in the mix M2, followed by the mix M4. This is thought to be due to improved densification of the cement matrix and also to stronger bonding in the inter-facial zone between the cement paste and aggregates. Compressive strength is found to have an increase of about 16.5% in M2, 11% in M4 and 6% in M3 at 7 and 28 days strength. From the comparison made between compressive strengths of cubes and cylinders following results were obtained. 42.28% and 35.4% for M2, 34.83% and 25.6% for M4 and 23.45% and 11.58% for M3 increase in compressive strength at 60 days for cubes and cylinders respectively. Cubes are found to have an increase in strength of about 18% than cylinders at 60 days. Hence in case of compressive strength of cubes and cylinders silica fume is found to have better influence compared to fibres.
- Split tensile strength is found to have an increase of 27.9% & 26.9% for M3, 24.43% & 14.9% for M4 and 14.4% & 13.34% for M2 at 7 and 28 days respectively. M3 is found to have maximum increase also strength development is maximum at early age. It can also be concluded that polypropylene fibre if having better effect on split tensile strength of cylinders.
- Increase in strength is 24.16% & 32.7% for M3, 16.45% & 19.69% for M4, 3.85% & 2.91% for M2 in case of flexural strength at 7 and 28 days respectively. It can be noted that strength development is larger at early age and addition of fibre shows better results. Thus flexural strength is found to have better enhancement compared to split

tensile strength with addition of fibres. Also increase in split tensile strength and flexural strength due to addition of silica fume is not much significant.

- Modulus of elasticity is found to be maximum in M3 ie. 31.75 GPa. This value is almost 36.62% higher than conventional concrete. M4 and M2 have 28.59% and 25.38% increase respectively. Modulus of elasticity increased by the addition of fibre. Silica fume replacement has not contributed much to the increase of modulus of elasticity. The combination of both has a better effect on the same. Poisson's ratio is maximum for M4 mix. It shows that including both fibres and silica fume in concrete will have a positive effect on poisons ratio.
- Density values obtained was maximum for M2 and minimum for M4 in case of both cubes and cylinders. Thus including mineral admixture like silica fume will increase density of concrete.

3) Conclusions from durability tests conducted:

- The action of acids on concrete is the conversion of calcium compounds into calcium salts of the attacking acid. These reactions destroy the concrete structure. The percentage of loss in compressive strength was 11.91%, 8.18%, 9.78%, 6.44% for M1, M2, M3, and M4 respectively. Thus addition of fibre and silica fume is found to have increased the durability against acid attack. This is due to the silica present in silica fume which combines with calcium hydroxide and reduces the amount susceptible to acid attack. The fibres present will help in better bonding and thereby reducing cracks and permeability.
- Percentage loss in compressive strength due to sulphate attack are as follows.7.87%, 4.98%, 6.10% and 5.45% for M1, M2, M3, and M4 respectively. M2 is having highest resistance to sulphate attack. Thus silica fume offers better durability to sulphate attack. The silica fume present helps in better particle packing due to its fineness and reducing ingress of sulphate solution. Also chemical properties of silica fume contribute to resistance to sulphate attack.
- Saturated water absorption is a measure of pore volume or porosity in concrete. The water absorption value is found to be decreased with the addition of silica fume. This is due to improved particle packing of silica fume which reduces volume of pores in concrete structure. The mix M2 shows least value of water absorption and thus improved durability compared to other mixes. The value is 1.89% which is 10.7% lower than water absorption in M1 ie. Conventional concrete. Porosity is reduced with the addition of silica fume and fibre together. The mix M4 shows least porosity ie. 2.15 which is almost 34% lower than porosity conventional concrete.
- Water permeability due to initial surface absorption was minimum in M2. Thus it proves that addition of silica fume in concrete reduces water permeability and thereby increasing the durability of concrete.
- Loss in compressive strength at lower temperature is due to dehydration and air void formation. This causes decomposition and formation of cracks in cement particles. Maximum compressive strength is obtained for M4 at all temperatures. This is due to stronger binding forces between paste and aggregates, provided by silica fume and polypropylene fibres added which gives better thermal stability. Hence addition of both fibres and silica fume is found to have enhanced durability. The strength values are found to be decreasing as temperature was increased. The decrease was less than10%, 8.5% and 5% at 100°C, 200°C and 300°C respectively. At higher temperatures it is said that fibres melt and this results in formation of pores in the matrix which has resulted in the reduction of strength in the mix M3 in which only fibre was used.

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