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Studies on Effect of Silica Fume by Partial Replacement of Coarse Aggregate & Cement with Plastic Granules & Fly Ash

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Abstract:
Effort towards preserving natural coarse aggregate for future generation, an investigation has been made to fulfil the demand of coarse aggregate up to some extent. The present study is about the effect on partial replacement of plastic granules and optimum fly ash content and silica fume on properties of concrete, by different proportions, and individual trial mixes are made for different compositions, with and without addition of silica fume. An auxiliary test like compression, split tensile, flexural strength test was made on cubes, cylinders, beams for 7, 28, 90,120days. Durability tests were made on cubes by using HCL (OR) H2SO4 solutions or sea water. A comparative study has been done between conventional concrete and partial replaced concrete with and without using of silica fume**.** The fly ash is a pulverized fuel ash is a coal combustion product composed of fine particles driven out of the boiler from flue gases. Fly ash includes substantial amounts of silicon dioxide (SiO_2) (both amorphous and crystalline), aluminum oxide (Al_2O_3) and calcium oxide (CaO), the main mineral compounds in coal-bearing rock strata. The Study Has Been Made to Evaluate the Effect on Mechanical and Durability Properties of M_{30} Grade Concrete with Various Proportional of partial Replacement of Coarse aggregate with plastic (0%, 10%, 20%, 30%&40%) By Weight and optimum percentage of 20% of cement with flyash and 5% of silica fume to improve strength

Keywords: Silica fume, flyash, plastic granules, concrete, split tensile, flexural strength

1. INRODUCTION

In this world, there is great demand of aggregates mainly from civil engineering industry for road and concrete constructions. But now days it is very difficult problem for available of coarse and fine aggregates. So researchers developed waste management strategies to apply for replacement of these aggregates for specific need. Natural resources are depleting worldwide while at the same time the generated wastes from different areas are increasing substantially. The sustainable development for construction involves the use of nonconventional and innovative materials, and recycling of waste materials in order to compensate the lack of natural resources and to find alternative ways conserving the environment

2. PROPERTIES OF MATERIALS

2.1 Cement: Cement is the main constituent in manufacturing of concrete. The characteristics like strength and bonding of concrete will be greatly affected by changing the cement content. Cement used in this experiment is Ordinary Portland Cement (OPC) locally available in Vijayawada (the KCP CEMENT Brand Name) in 50kg bags was used for the experiment.

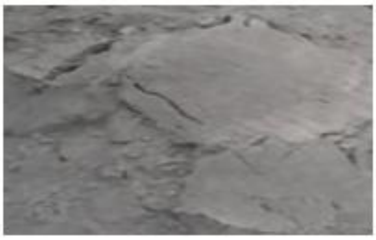


Figure.2.1 Cement

Table .1. physical properties of cement

S.No	Properties	Value
1	Specific Gravity	3.15
2	Initial setting time	42min
3	Final setting time	256 min
4	Normal consistency	32%
5	Fineness test	5% retained

2.2 Fine Aggregate

The aggregate size is lesser than 4.75 mm is considered as fine aggregate. The sand particles should be free from any clay or inorganic materials and found to be hard and durable. It was stored in open space free from dust and water. In our region fine aggregate can be found from bed of Krishna River. It conforms to IS 383-1970 comes under zone I0I.

Figure.2.2 Fine Aggregate

Table.2. Properties of Fine Aggregate

S.No	Properties	Value
1	Specific Gravity	2.6
2	Density kg/m³	1580
3	Water absorption	
4	Zone	II

2.3 Coarse Aggregate

The aggregate size bigger than 4.75 mm, is considered as coarse aggregate. It can be found from original bed rocks. Coarse aggregate are available in different shape like rounded, Irregular or partly rounded, Angular, Flaky. It should be free from any organic impurities and the dirt content was negligible

Figure.2.3 Coarse Aggregate

Table.3. Properties of Coarse Aggregate

S.No	Properties	Value
1	Specific Gravity	2.70
2	Crushing value	14.21%
3	Impact value	2.5%

2.4 Fly ash

Fly ash is a finely divided powder obtained from the combustion of bituminous coal or sub-bituminous coal (lignite). It is also known as Flue Ash. It is available in large quantities in the country as a waste material which is obtained at the thermal power plants. Fly Ash is used as a partial replacement of cement for cement mortar and concrete and this has been taken into consideration from the recent years in the countries. The recent investigations have declared that it is necessary to investigate the proper collection methods for fly ash of quality and uniformity which requires for fly ash for use as a construction material. Fly Ash is a mineral portion of coal consumed in a coal fuel power plant. The particles of Fly Ash are spherical shaped, glassy and finer than cement particles.

Figure.2.4 Fly Ash

Table .4. physical Properties of Fly ash

S.No	Properties	Fly ash
1	Fineness	3%
2	Bulk density, Kg/m³	1.12gm/cc
3	Specific gravity	2.52
4	Colour	Grey

Table .5. chemical Properties of Fly ash

S. No	Major Components	Fly Ash
01	Silicon Dioxide SiO_2	55.59%
02	Aluminium Oxide Al_2O_3	26.64%
03	Ferric Oxide Fe_2O_3	9.50%
04	Calcium Oxide CaO	2.30%
05	Magnesium Oxide MgO	0.60%

2.5 Plastic

Waste trash bag plastics were collected from the landfill and from other locations in the environment and used to manufacture light weight aggregates. The plastic waste sheet was shaped as desired, e.g.. The plastic waste aggregate was modified by heat treatment (160°C- 200°C) in Plastic Granule Recycling Machine. Then, the hot aggregate was removed from the Machine and allowed to cool at room temperature, but they were a mixture of angular shapes and round shapes, much like crushed stone. And they obtained plastic granules are grinded in a grinding mill to a 20mm down size. Plastics collected from the disposal area were sorted to get the superior one. These were crushed into small fraction and washed to remove the foreign particles. Then it was heated at a particular temperature so that the necessary brittleness was obtained. After extrusion the molten plastic was cooled down and collected in boulders of 100 mm size approximately. These plastic boulders were crushed down to the size of aggregates.

Figure.2.5 plastic granules

Table.6. (properties of plastic)

S.No	Properties	plastic
1	Maximum aggregate size mm	20.0
2	Bulk density, Kg/m^3	1510
3	Specific gravity	2.18
4	24-hour water absorption (%)	0
5	Fineness modulus	5.38

2.6 SILICAFUME

Silica fume is also known as micro silica, condensed silica fume, volatized silica or silica dust. It is usually a grey colored powder, somewhat similar to Portland cement or some fly ashes. It can exhibit both pozzolanic and cementitious properties. Silica fume has been recognized as a pozzolanic admixture that is effective in enhancing the mechanical properties to a great extent. Silica fume was produced from ASTRA CHEMICALS in Chennai. The Silica fume is used as an admixture to the cement.

Figure. 2.6 Silica fume

Table.7. physical Properties of Silica Fume

S.No	Properties	Silica fume
1	Fineness	15,000 to35,000
2	Bulk density(kg/m^3)	1350-1510
3	Specific gravity	2.63

Table .8. Chemical Properties of Silica Fume

S. No	Major Components		Cement	Silica fume
01	Silicon Dioxide	SiO_2	20.0%	99.886%
02	Aluminium Oxide	Al_2O_3	4.90%	0.043%
03	Ferric Oxide	Fe_2O_3	2.30%	0.040%
04	Calcium Oxide	CaO	65.0%	0.001%
05	Magnesium Oxide	MgO	3.10%	0.00%
06	Sodium Oxide	Na_2O	0.20%	0.003%
07	Potassium Oxide	K_2O	0.40%	0.001%
08	Sulphur Oxide	SO_3	2.30%	-

3. EXPERMENTAL PROGRAM

General

The experimental program was carried out on cubes, cylinders and beams. The details of the materials Used for these specimens and testing procedure incorporated in the test program are presented in the subsequent sections.

3.1METHOD

The Plastic waste is dried in the open air to clean out the dirt. This waste was first of all broken down to our coarse aggregate sizes carefully. The size of this waste should be as coarse aggregate sizes. These waste aggregates were used as partial replacement of conventional coarse aggregates in concrete cube, cylinder, and beam specimens up to 40% .The specimens are made for M30 grade concrete. Concrete mix ratio of with a water/cement ratio of 0.45 respectively has been used in the study In addition to that cement is partial replaced with fly ash by an optimum content i.e., 20% the optimum content of fly ash is taken because the usage of fly ash content is restricted to 30% above this content the strength of the concrete is decreases. Besides to that an admixture is used to improve the strength to the concrete. An admixture silica fume is used in the present study because as far as project concerned use of plastic waste gives less strength. To increase the strength and admixture silica fume is used. Percentage level of silica fume is 5%because it is a pozzolanic material which gives high strength. The present study is about the effect of partial replacement of plastic waste up to 40% and optimum fly ash content 20% on properties of concrete, and individual trial mixes are made for these proportions without addition of silica fume in the first set. And another set is made by using silica fume to the above cement and coarse aggregate proportions and these test results are compared. The different tests conducted in laboratories are shown in this paper. It consist mixing of concrete in the laboratory by replacing plastic waste as Coarse aggregate with proportions (by volume) of plastic waste added to concrete mixtures were as follows: 0% (for the control mix), 10%, 20%, 30%, 40% and cement with optimum fly ash content without using silica fume. Concrete samples were prepared and cured in the laboratory, and are tested, to evaluate compressive, split tensile and flexural strength. Another concrete mixture was made as done above by using silica fume.

3.2Casting

Casting is done for cubes, cylinders and beams to study the compressive split and flexural strength of concrete.

- Cubes specimens are of sizes 150 x 150 x 150 mm, were prepared and tested at 7, 28, 90,120 of curing in water, Sea water and Acid water under controlled laboratory conditions are casted for testing of compressive strength.
- Cylinders specimens are of sizes 300 x 150 mm, were prepared and tested at 7, 28 ,90,120 of curing in water ,Sea water and Acid water under controlled laboratory conditions are casted for testing of split tensile strength.
- Beams specimens are of sizes 500mm x 100mm x 100 mm were prepared and tested at 7, 28, 90,120 of curing in water, Sea water and Acid water under controlled laboratory conditions are casted for testing of flexure strength

Figure.3.1 Casting

3.3Curing

Curing is done for casted specimens with normal water, sea water and acid curing. Of all these specimens are cured water, in normal sea water and acid curing is done for durability tests. Normal water curing is the main process to get the strength for the specimens. The water for curing is free from impurities and high salinity. The cubes should be remolded after 24 hours of casting and after that keep the specimens in required solutions for curing at room temperatures with a relative humidity of 85%. In general the specimens are taken out from curing after 7 days, 28 days, 90 days & 120 days for testing.

For calculating the durability studies sea water curing and acid curing is done for the specimens.

Figure.3.2Watercuring

Figure.3.3SeaWater curing

Figure.3.4Acid curing

4. TESTING OF CONCRETE

4.1Compressive Strength Test:

According to IS 516-1959 After 28 days of curing, the cubes were taken out from curing tank, dried and tested using a compression testing machine. These cubes were loaded on their sides during compression testing such that the load was exerted perpendicularly to the direction of casting. The cubes were placed in the compression testing machine and the loads are applied gradually at a rate of 16.3 $N/mm^2/min$. The average value of the compression strength of three cubes was taken as the compression strength. The compressive strength of conventional concrete was found to be 27.63 N/mm^2.The compressive strength of concrete with both crusher dust and blast furnace slag are given in Table 6.1

Compressive strength = P/A

Where, P = Compressive load (kN)

A = Area of the cube (150 X 150 mm)

The cubes are tested for compressive strength of sizes 150 x 150 x 150 mm, are commonly used After 24 hours these moulds are removed and test specimens are put in water for curing. These specimens are tested by compression testing machine after 7, 28, 90,120days of curing.

Figure.4.1Compression test

Figure.4.2casting of cubes

4.2split Tensile Strength According to IS 5816-1999. The cylindrical specimens of diameter 150mm and height 300mm were used to determine the split tensile strength. The specimens were tested in compression testing machine of capacity 2000 kN. Three cylindrical specimens were tested for each percentage of replacement. The cylinders were placed in the machine horizontally. Load was applied gradually at a uniform rate until the specimens failed. Split tensile strength was taken as the average strength of three specimens. The cylinders are casted for calculating tensile strength of concrete. To calculate this tensile strength cylinders of 300 x 150 mm, were prepared and tested at 7, 28 ,90,days of curing.

split tensile strength **Fcr** $=2P/\pi DL$

Where, P = Split tensile load

D = Diameter of the specimen (150 mm)

L = Length of the specimen

A = cross sectional area of the specimen in mm^2

Figure.4.3 split tensile strength test

4.3Flextural Test: According to IS 516-1959

The prism specimens of size 500 x 100 x 100 mm were used for the determination of the flexural strength. The bearing surface of the supporting and loading rollers were wiped clean and any other loose fine aggregate or other materials removed from the surface of the specimen where they are to make contact with the rollars. The specimen was then placed in the machine and two point loads was applied. Load was increased until the specimen failed and the load at failure was recorded and the flexural strength was determined. Flexural strength was taken as the average strength of three specimens. Test specimens were prepared by moulding concrete to a beam section, curing and storing in accordance with standard procedure. The section of the beam was square of 100 mm. The overall length of the specimen was 500 mm. Size (100x100x500) mm. The specimen stored in water was tested immediately on removal from water. The test specimen was placed in the machine correctly centered with the longitudinal axis of the specimen at right angles to the rollers. For specimens, the mould filling direction shall be normal to the direction of loading.

Flexural strength = M/Z N/mm^2

Where M is bending moment in N-mm

Z is section modulus of the specimen in mm^3.

Figure.4.4 Flexure strength test

Table.9. Mix proportion ratio for M30 Grade

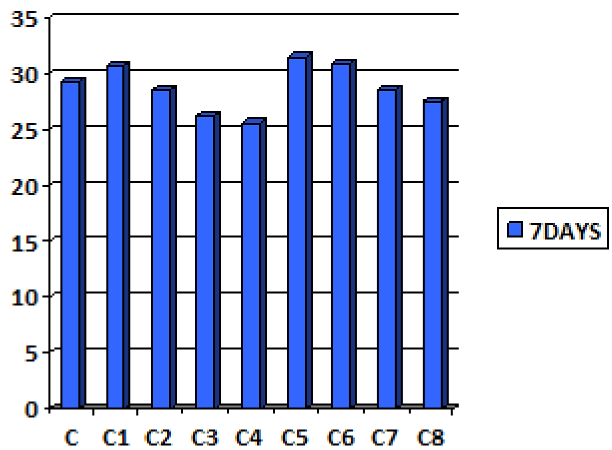
Cement Kg/m^3	Fine aggregate Kg/m^3	Coarse aggregate Kg/m^3	Water l/m^3
425.33	619.71	1195.155	186
1	1.45	2.80	0.45

5. RESULTS AND DISCUSSIONS

5.1. Compressive Tests Results:

Table.10. Compressive strength for 7 days (Mpa) :

s.no	mix proportion	water curing
1	C	29.30
2	C1	30.69
3	C2	28.56
4	C3	26.28
5	C4	25.65
6	C5	31.54
7	C6	30.87
8	C7	28.64
9	C8	27.56

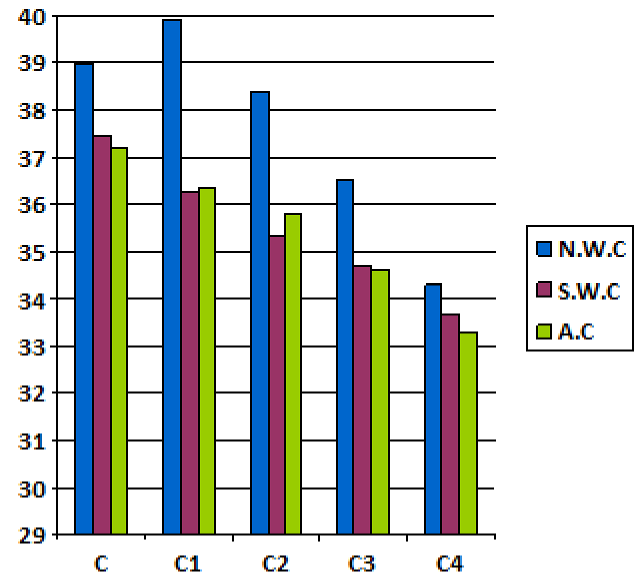


Mix proportion

Figure.5. 1 Graph for Compressive Strength results of 7daysWater, Curing (with &without silica fume):

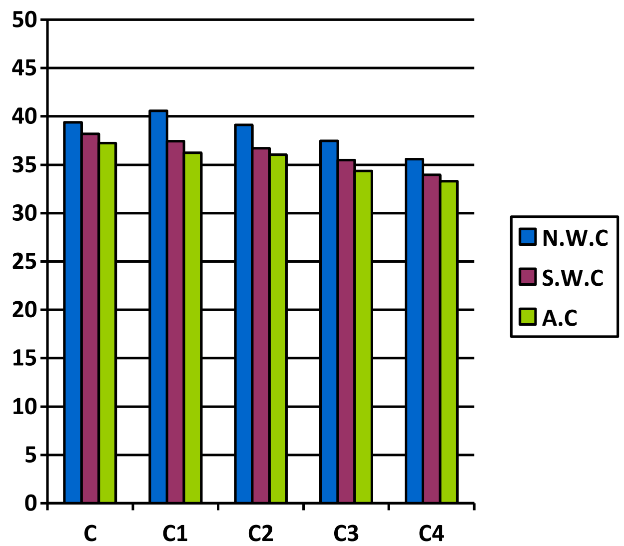
Table.11. Compressive strength for 28, 90, 120days

Mix	28days			90days			120days		
Without silica fume									
	N.W.C	S.W.C	A.C	N.W.C	S.W.C	A.C	N.W.C	S.W.C	A.C
C	38.97	37.45	37.21	39.37	38.21	37.25	40.23	38.38	38.26
C1	39.90	36.26	36.34	40.58	37.43	36.24	40.95	37.94	37.16
C2	38.37	35.35	35.82	39.12	36.72	36.06	40.12	36.24	34.68
C3	36.54	34.68	34.57	37.47	35.48	34.36	38.73	33.26	33.67
C4	34.29	33.65	33.27	35.58	33.96	33.29	36.45	32.12	32.65
With silica fume									
C5	41.65	39.56	38.23	42.36	40.36	39.26	41.69	40.46	39.26
C6	41.69	38.67	38.10	42.59	39.46	38.17	40.72	39.19	38.57
C7	39.92	38.39	37.21	40.25	39.15	38.10	39.29	38.54	38.16
C8	38.24	37.54	36.52	39.64	38.16	37.72	39.13	37.29	37.17



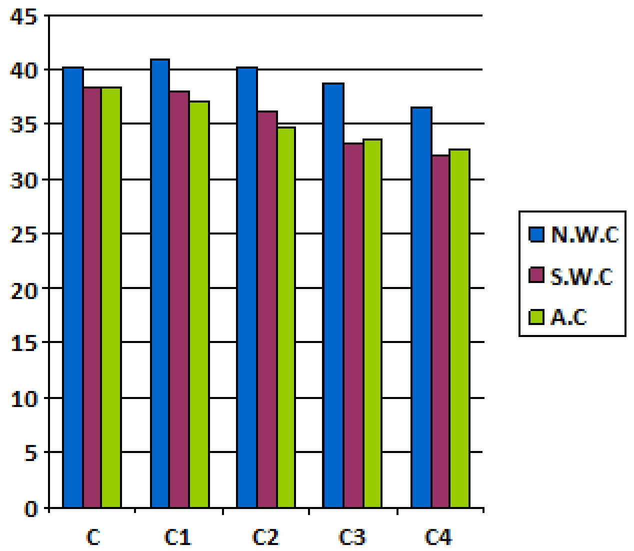
Mix proportion

Figure.5.2Graph for Compressive Strength results of 28days (without silica fume):



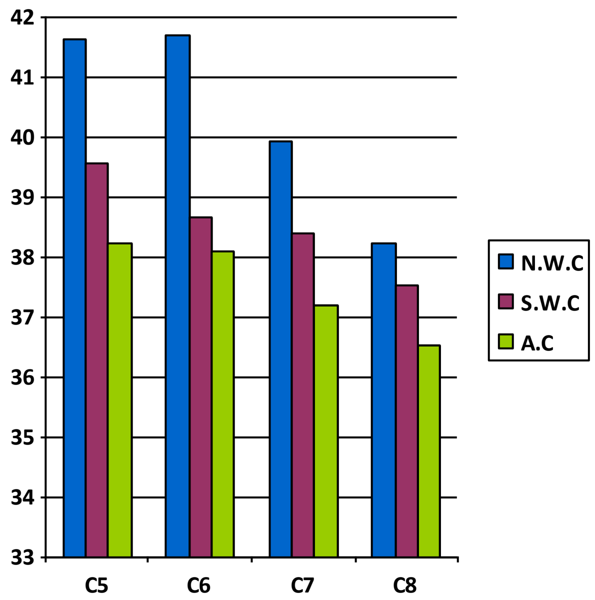
Mix proportion

Figure.5.3 Graph for Compressive Strength results of 90days(without silica fume):



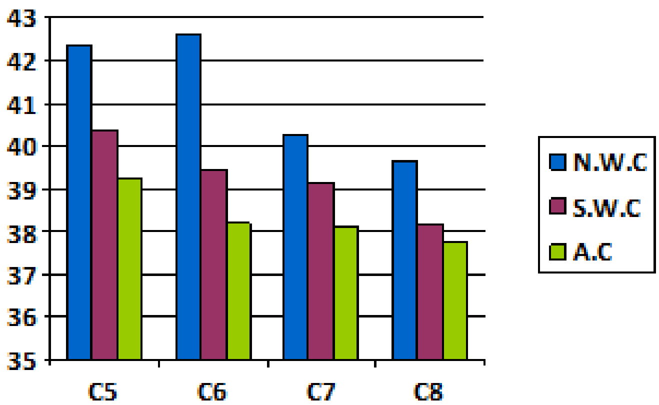
Mix proportion

Figure.5.4 Graph for Compressive Strength results of 120days (without silica fume):



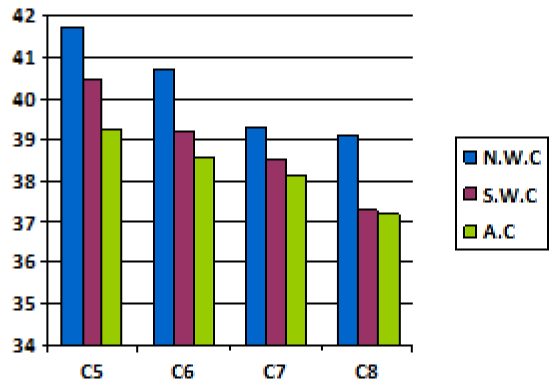
Mix proportion

Figure.5.5 Graph for Compressive Strength results of 28days (with silica fume):



Mix proportion

Figure.5.6 Graph for Compressive Strength results of 90 days (with silica fume):



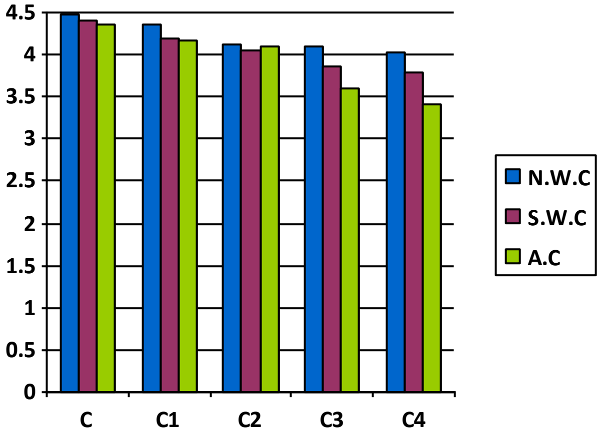
Mix proportion

Figure. 5.7 Graph for Compressive Strength results of 120days (with silica fume):

5.2 Split Tensile strength results

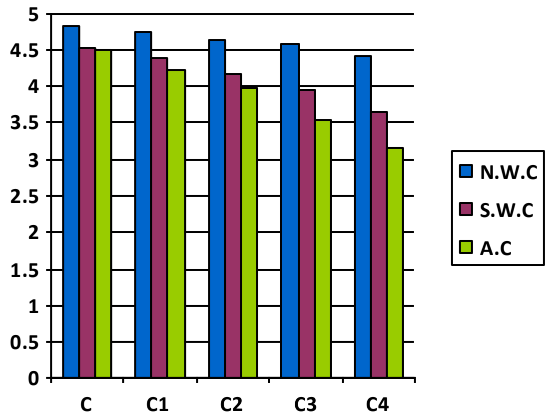
Table.12. Split Tensile Strength for 28 ,90 and 120 days

Mix	28days			90days			120days		
Without silica fume									
	N.W.C	S.W.C	A.C	N.W.C	S.W.C	A.C	N.W.C	S.W.C	A.C
C	4.48	4.40	4.35	4.82	4.52	4.49	4.89	4.65	4.17
C1	4.35	4.20	4.17	4.75	4.39	4.21	4.72	4.48	4.28
C2	4.13	4.05	4.09	4.62	4.16	3.98	4.68	4.15	3.78
C3	4.09	3.85	3.59	4.57	3.95	3.53	4.42	3.98	3.42
C4	4.02	3.79	3.42	4.41	3.64	3.16	4.29	3.63	3.28
With silica fume									
C5	4.58	4.54	4.49	4.98	4.69	4.65	5.25	5.08	4.87
C6	4.62	4.59	4.54	4.86	4.62	4.59	5.10	4.73	4.53
C7	4.36	4.32	4.29	4.65	4.42	4.36	4.86	4.59	4.23
C8	4.23	4.21	4.17	4.52	4.34	4.29	4.45	4.12	4.10



Mix proportion

Figure.5.8 Graph for Split tensile Strength results of 28days (without silica fume):



Mix proportion

Figure.5.9 Graph for Split tensile Strength results of 90days (without silica fume):

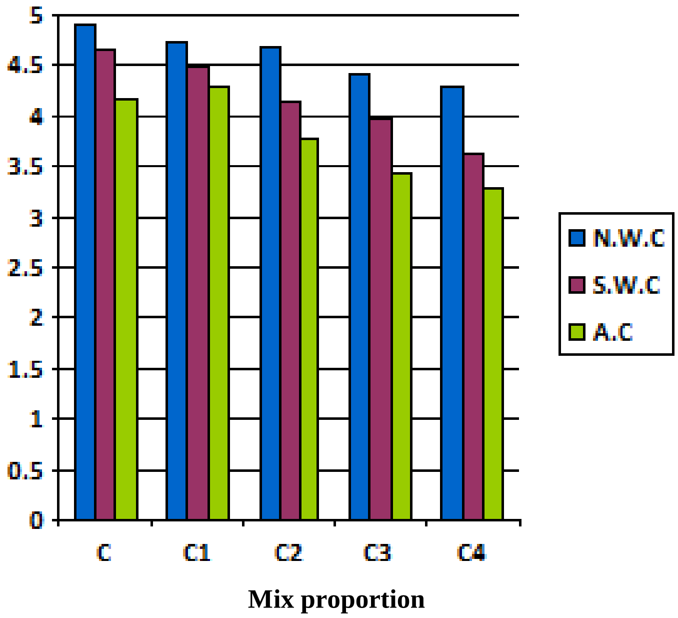


Figure. 5.10 Graph for Split tensile Strength results of 120 days (without silica fume):

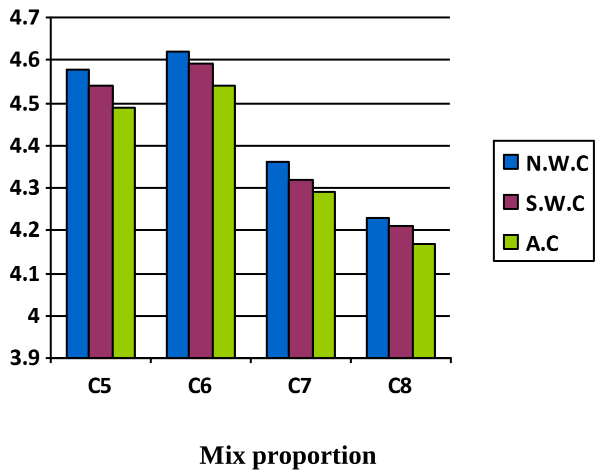


Figure. 5.11 Graph for Split tensile Strength results of 28days(with silica fume):

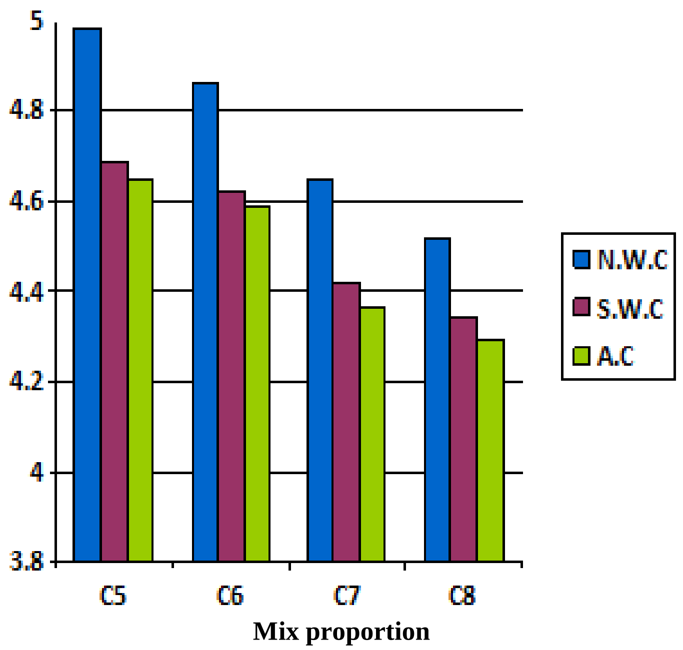


Figure. 5.12 Graph for Split tensile Strength results of 90days (with silica fume):

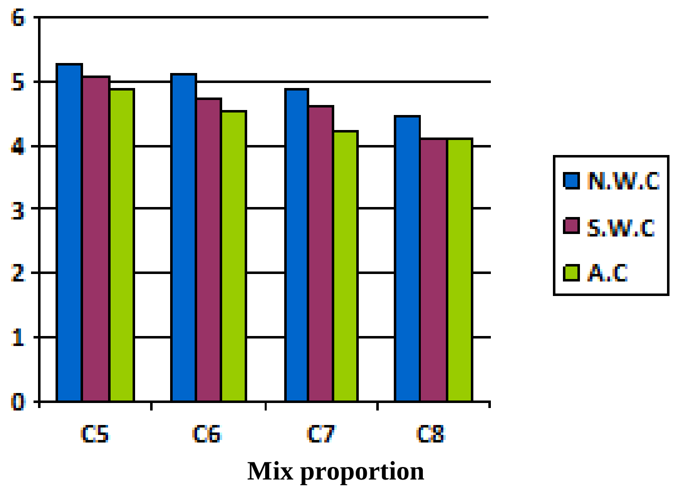


Figure. 5.13 Graph for Split tensile Strength results of 120days (with silica fume):

5.3Flexural Strength results

Table.13. Flexural Strength for 28days water curing in mpa:

S.No	Mix Proportion	Water curing
1	C	6.36
Without silica fume		
2	C1	6.23
3	C2	6.06
4	C3	5.96
5	C4	5.87
With silica fume		
6	C5	6.85
7	C6	6.57
8	C7	6.29
9	C8	6.02

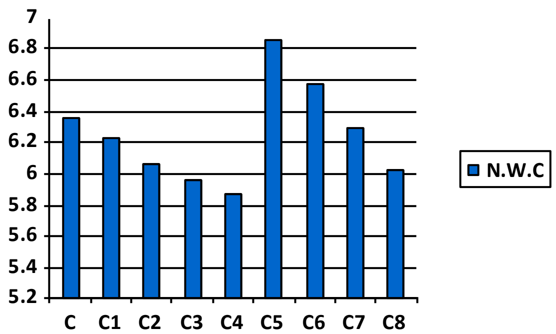


Figure.5.14 Graph for Flexural Strength results of 28days(with & withoutsilica fume):

6. STUDY ON DURABILITY PROPERTIES

6.1Durability of Concrete

6.1.1Durability

Concrete or plastic concrete is a freshly mixed material which can be moulded into any shape. The relative quantities of cement, aggregates and water mixed together, control the properties of concrete in wet state as well as in hardened state. For a long time, concrete was considered to be very durable material requiring a little or no maintenance. The assumption is largely true except when it is subjected to highly aggressive environments. Concrete structures are built in highly polluted urban and industrial areas, aggressive marine environments, coastal areas and many other hostile conditions. Since the use of concrete in recent years, have spread to highly harsh and hostile conditions, the earlier impression that concrete is a very durable material is being threatened, particularly on account of premature failures of number of structures in recent past. It was in 1930's when it was found that series of failures of concrete pavements have taken place due to frost attack. Although compressive strength is a measure of durability to a great extent it is not entirely true that strong concrete is always a durable concrete. For example it is structurally possible to build a jetty pier in marine conditions with 20 Mpa concrete, environmental conditions can lead this structure to disastrous consequences. In addition to strength of concrete another factor, environmental condition or exposure condition has become an important consideration for durability.

7. CONCLUSIONS

From the above test results in this research following conclusions has been drawn from the study:

- From the test results, it can be seen that the compressive strength of plastic waste concrete mixes with 10%, 20%, 30%, 40%, by coarse aggregate replacement with plastic waste, and cement with optimum fly ash content there is slightly increase in compressive strength at 10%, 20% and after the strength was decrease.
- At 20% replacement of plastic waste and 20% optimum fly ash content increases the compressive strength, and strength decreases gradually with increase in percentages levels.
- Tensile and Flexure strength also decreases with increase in percentage levels of plastic waste.
- The compressive strength of concrete is increased by adding silica fume.
- Target mean strength of concrete is achieved by adding 5% replacement of silica fume at 40% replacement of plastic waste.
- Tensile and flexure strength are also increases by adding silica fume in concrete.
- By adding plastic waste in concrete reduces bulk mass density of concrete since it doesn't absorb water, fly ash is added so that mixture attains proper consistency and workability.
- It was found that the use of plastic waste decrease the strength of concrete.
- The mechanical or strength properties of plastic concrete improved up to the certain percentages of natural coarse aggregate substituted by plastic waste.
- The Durability properties are good at 90 days and 120 days of curing for the plastic incorporated concrete by using silica fume in concrete.
- It is evident that durability results are also increases the compressive strength of concrete at 10%, 20% mixes increases and decrease with age.
- It can be evident that 40% replacement of plastic waste with silica fume and optimum fly ash content is achieving the target mean strength of concrete..
- In Sea-Water Curing and Acid Curing at 20% replacement of plastic waste compressive strength is high with 5% replacements of silica fume.
- Split-Tensile strengths are increased at 10%,20%of plastic waste and 20% fly ash with addition of and then decreased in 90,120 days acid and sea water curing.

8. FURTHER SCOPE OF WORK

- Flexural Strength properties of concrete with partial replacement of coarse aggregate with plastic waste and optimum fly ash content with silica fume will need investigation for longer period i.e. 90and 120 days.
- Strength properties of concrete with partial replacement of coarse aggregate with plastic waste and optimum fly ash content with and without silica fume will need investigation for longer period i.e. 28, 90,120 days.
- The effect of temperature on this replaced concrete developed can be studied.

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