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STRENGTH PARAMETERS OF SELF COMPACTING CONCRETE WITH PARTIAL REPLACEMENT OF CEMENT BY FLY ASH AND SAND BY ROCK CRUSHED POWDER.

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***ABSTRACT** - Construction activity in India during the last decades has more than doubled. The utilization concrete all over the globe has made the constituents of this composite material to be in great demand. Concrete has been the most preferred construction material for over five decades. It is being increasingly used day by day all over the world due to its versatility, mould ability, high compression strength and many more advantages. The problems of how to meet the increasing demand and cost of concrete in sustainable manner is a challenge in the field of civil engineering and environmental studies.Necessity of use of alternative material is the need of the hour because of environmental and economic reason it requires thinking about the use of industrial waste as alternative materials in concrete production, which not only reduce the cost of production of concrete but also control the pollution leading to sustainable development. Concrete as a construction material has a large potential all over the world and net only to consumption of water. Aggregate contributing about 70%to80% of concrete mass, hence there exists a vast demand for aggregate.*

River sand is becoming a very scarce material. The sand mining from our rivers have become objectionably excessive in view of both economy and environment. Rock crush powder (RCP) can be used as an alternative to sand and its effect on the strength and properties of fresh concrete are needed to be investigated. Unfortunately limited research has been conducted to explore the potential utilization of RCP in concrete mixture. In view of the above investigation it is an attempt towards the assessment of suitability of use of Fly Ash (FA) and Rock Crushed Powder (RCP) in concrete production. The present experimental work consists of experimental studies are carried out to understand the strength characters of self compacting concrete with two replacement 10% and 20% of Fly Ash for cement and four different replacement levels for RCP for sand i.e.(0%,25%,50%,75%,100%.) in comparison to Conventional SCC for this experimental work the grade concrete used is M50.

Keywords: Self compacting concrete, conventional self compacting concrete, fly ash, rock crushed powder, super plasticizers, water, cement, sand, aggregate, compressive strength, split tensile strenght

1. INTRODUCTION

The importance of concrete in modern society cannot be underestimated. There is no escaping from the impact of concrete on everyday life. Concrete is a composite material which is made of filler and a binder. Typical concrete is a mixture of fine aggregate, coarse aggregate, cement, and water. Nowadays the usage of concrete is increasing from time to time due to the rapid development of construction industry.

Self-Compacting Concrete (SCC) was first developed in 1988 so that durability and workability of concrete structures can be improved. Since then, various investigations have been carried out and the concrete has been used in practical structures in Japan, mainly by large construction companies. Investigations for establishing a rational mix-design method and self-compatibility testing methods have been carried out from the viewpoint of making it a standard concrete. Recommendations and manuals for SCC were also established.

SCC is considered to be the most promising building material for the expected revolutionary changes at the job sites as well as on the desk of designers and civil engineers. However, the basic principles of this material are substantially based on those of flowing, cohesive, and super plasticized concretes developed in the mid of 1970's.

Owing to all its properties, use of SCC is constantly increasing all over the world. But the adoption has not been as fast as it should have been due to its higher cost of production. In India, SCC is used in limited owing to lack of awareness and the higher costs associated with its production. SCC is defined by two primary properties: Deformability and Segregation resistance. Deformability or flow ability is the ability of SCC to flow or deform under its own weight (with or without obstructions).

The content of coarse aggregate and the water to binder ratio in Self Compacting SCC are lower than those of normal concrete. Therefore SCC contains large amounts of fine particles such as palm oil fuel ash (POFA), blast-furnace slag, Fly ash in order to avoid gravity segregation of larger particles in the fresh mix.

The necessary ingredients for manufacturing SCC are Super plasticisers and powder materials (including cement, Fly ash, ground fillers or other mineral additions even in the form of fine recycled aggregate) at an adequate content (> 400

kg/m^3 of cement and filler), with some limits in the maximum size of the coarse aggregate (< 25mm).
Rock Crushed Powder (RCP) is a by-product generated from quarrying activities involved in the production of crushed coarse aggregates. RCP is used as an alternative of natural sand and its effects on the strength and workability of the concretes are investigated.
RCP which is generally considered as a waste material causes an environmental load due to disposal problem. Hence the use of utilization of Quarry rock dust which can be called as manufactured sand has been accepted as a building material in the industrially advanced countries of the west for the past three decades.

II. OBJECTIVES

In the present study the strength characters on SCC replacing both cement and Sand together by Fly Ash & Rock Crushed Powder respectively.

- Partially replacing Cement with Fly Ash
- High percentage replacing sand by rock crushed powder.

III. LITERATURE SURVEY

1) Paratibha Aggarwal (2008) et al presented a procedure for the design of self-compacting concrete mixes based on an experimental investigation. At the water/powder ratio of 1.180 to 1.215, slump flow test, V-funnel test and L-box test results were found to be satisfactory, i.e. passing ability; filling ability and segregation resistance are well within the limits. SCC was developed without using VMA in this study. Further, compressive strength at the ages of 7, 28, and 90 days was also determined. By using the OPC 43 grade, normal strength of 25 MPa to 33 MPa at 28-days was obtained, keeping the cement content around 350 kg/m3 to 414 kg/m3.

2) Girish (2010) et al presented the results of an experimental investigation carried out to find out the influence of paste and powder content on self-compacting concrete mixtures. Tests were conducted on 63 mixes with water content varying from 175 l/m3 to 210 l/m3 with three different paste contents. Slump flow, V funnel and J-ring tests were carried out to examine the performance of SCC. The results indicated that the flow properties of SCC increased with an increase in the paste volume. As powder content of SCC increased, slump flow of fresh SCC increased almost linearly and in a significant manner. They concluded that paste plays an important role in the flow properties of fresh SCC in addition to water content. The passing ability as indicated by J-ring improved as the paste content increased.

3) Production of Self–compacting Concrete Using Crusher Rock and Marble Sludge Dusts. By M.Shahul Hameed, P. Kathirvel, Dr.A.S.S. Sekar, (2010)
For many decades, concrete has largely been used as a construction material, whether in moderate aggressive environment, or in strong aggressive environment. By volume alone, concrete is the world's most important construction material. Self–compacting Concrete (SCC) as the name implies that the concrete requiring a very little or no vibration to fill the form homogeneously. SCC is defined by two primary properties: Ability to flow or deform under its own weight (with or without obstructions) and the ability to remain homogeneous while doing so.
The study explores the use of marble sludge dust (MSD) and crusher rock dusts (CRD) to increase the amount of fines and hence achieve self-compactibility in an economical way, suitable for Indian construction industry. The study focuses on comparison of fresh properties of SCC containing varying amounts of MSD and CRD with that containing commercially available viscosity modifying admixture. The comparison is done at different dosages of super plasticizer keeping cement, water, coarse aggregate, and fine aggregate contents constant. The possibility of developing low cost SCC using crusher rock and marble sludge dusts is feasible.
Low cost SCC can be made, by incorporating this industrial waste by replacing the river sand. The utilization of MSD and CRD in SCC solves the problem of its disposal thus keeping the environment free from pollution and enhance the resource productivity of the concrete construction industry. The replacement of fine aggregate with 30% marble sludge and 70% Crusher dust (Mix B) gives an excellent result in strength aspect and quality aspect. It induced higher compressive strength, higher splitting tensile strength. The results showed that the substitution of 70% of the crusher and 30% of marble sludge induced easier flow ability, pump ability, and compact ability. Early-strength up to 7 days, which can be accelerated with suitable changes in the mix design when earlier removal of formwork or early structural loading is desired.

IV. AIM AND SCOPE OF THE PRESENT INVESTIGATION

General

SCC has been developed in late 1980’s and by the year 2000 SCC had become popular in Japan. Till today investigations on SCC are being carried out to study and understand the dual characteristic properties of SCC in fresh state as well as in the hardened state.
From the previous study it is observed that study has been made on SCCs with replacement of cement with fly ash and Fine aggregate (Sand) with RCP. But the studies on SCC with replacement of both cement & Fine aggregate with FA and RCP together have not been studied. Hence in the present study the strength parameters of Self compacting Concrete using both fly ash & Rock crushed powder together has been studied and it is designated as FA & RCP SCC.

Aim of the present investigation
SCC with both Fly Ash & RCP as replacement to cement & FA for various replacement levels
Object of the present investigation are to be:
Study of strength parameters on the Fly Ash (FA) and Rock Crushed Powder (RCP) self compacting concrete replacing cement with FA at two different levels (10% & 20%), and sand with RCP at four different levels of replacement (0%, 25%, 50%, 75%,100%). Obtained strength parameters are compared with Conventional SCC(C) of M50 Grade concrete for different curing periods.
Scope of present investigation Strength parameters of Fly ash and RCP
Experimental studies are carries out to understand the strength characteristics of Fly ash & RCP SCC. The compressive strength, split tensile strength and flexural strength of Fly ash and RCP concrete is compared with Conventional SCC (C).

1. **Constant Parameters:**

- **Grade of Concrete** : M50
- **Water cement ratio (W/C)** **:**0.35
- **Size and No of Specimens** **:** Cube specimen of size 150mm x 150mm x150mm for compression tests.

Cylinder specimen of size 150mm diameter and 300mm long for split tensile tests.
Prism specimen of size 150mm x 150mm x 700mm long for Flexure tests.

2. **Variable parameters:**

- **Cement:** The cement is replaced by Fly ash in two different replacement levels of 10% and 20%.
- **RCP:** The natural sand is replaced by RCP in five different replacement levels of 0%, 25%.50%, 75%,100%.
- **Curing period:** To study compressive strength, split tensile strength and flexural strength development, the specimens are cured for 28 and 56 days
- **Super plasticizer:** super plasticizer Glenium B233 is used to maintain the workability with constant water binder ratio. Dosage is adjusted with in permissible limits such that concrete to maintain the required workability.

Table 1 No. of specimen of conventional SCC and FA & RCP SCC for Compressive strength

Sl. No	Concrete	Percentage replacement		Designation	Curing Period in days	
		FA	RCP		28	56
1	Conventional	0%	0%	C	3	3
2	FA &RCP SCC(with 10 % FA)	10%	0%	A0	3	3
3		10%	25%	A1	3	3
4		10%	50%	A2	3	3
5		10%	75%	A3	3	3
6		10%	100%	A4	3	3
7	SF &RCP SCC(with 20 % SF)	20%	0%	B0	3	3
8		20%	25%	B1	3	3
9		20%	50%	B2	3	3
10		20%	75%	B3	3	3
11		20%	100%	B4	3	3
Total No of Cubes					33	33

Table 2 No. of specimen of FA &RCP self compacting concrete for split Tensile strength

Sl. No	Concrete	Percentage replacement		Designation	Curing Period in days	
		FA	RCP		28	56
1	Conventional	0%	0%	C	3	3
2	FA &RCP SCC(with 10 % FA)	10%	0%	A0	3	3
3		10%	25%	A1	3	3
4		10%	50%	A2	3	3
5		10%	75%	A3	3	3
6		10%	100%	A4	3	3
7	SF &RCP SCC(with 20 % SF)	20%	0%	B0	3	3
8		20%	25%	B1	3	3
9		20%	50%	B2	3	3
10		20%	75%	B3	3	3
11		20%	100%	B4	3	3
Total No of Cubes					33	33

Table 3 No. of specimen of Conventional SCC, FA& RCP SCC for Flexural Strength

Sl. No	Concrete	Percentage replacement		Designation	Curing Period in days	
		FA	RCP		28	56
1	Conventional	0%	0%	C	3	3
2	FA &RCP SCC(with 10 % FA)	10%	0%	A0	3	3
3		10%	25%	A1	3	3
4		10%	50%	A2	3	3
5		10%	75%	A3	3	3
6		10%	100%	A4	3	3
7	SF &RCP SCC(with 20 % SF)	20%	0%	B0	3	3
8		20%	25%	B1	3	3
9		20%	50%	B2	3	3
10		20%	75%	B3	3	3
11		20%	100%	B4	3	3
Total No of Cubes					33	33

V. FRESH CONCRETE TESTS FOR SELF COMPACTING CONCRETE

Flow ability: The Flow ability is measured by using slump cone test. As the slump value of FA & RCP SCC decreases for 20% replacement of FA comparing to 10% replacement of FA, the slump value decreases due to the reduction in flow ability.

The dosage of Super plasticizer is made restricted to 0.6% based on the mass cone method with water binder ratio 0f 0.35 to get the value within the permissible codal value. The slump value of SCC with 10% and 20 % FA for different level of RCP has been tabulated in the Table 4

Table 4. Slump Values

Sl. No	Concrete Designation	Percentage replacement of		Designation	Water Binder Ratio	Slump Values in mm.
		FA	RCP			
1	Conventional	0%	0%	C	0.35	708
2	FA & RCP SCC(with 10% FA)	10%	0%	A0	0.35	698
3		10%	25%	A1	0.35	692
4		10%	50%	A2	0.35	690
5		10%	75%	A3	0.35	691
6		10%	100%	A4	0.35	690
7	FA &RCP SCC(with20% FA)	20%	0%	B0	0.35	690
8		20%	25%	B1	0.35	688
9		20%	50%	B2	0.35	686
10		20%	75%	B3	0.35	687
11		20%	100%	B4	0.35	685

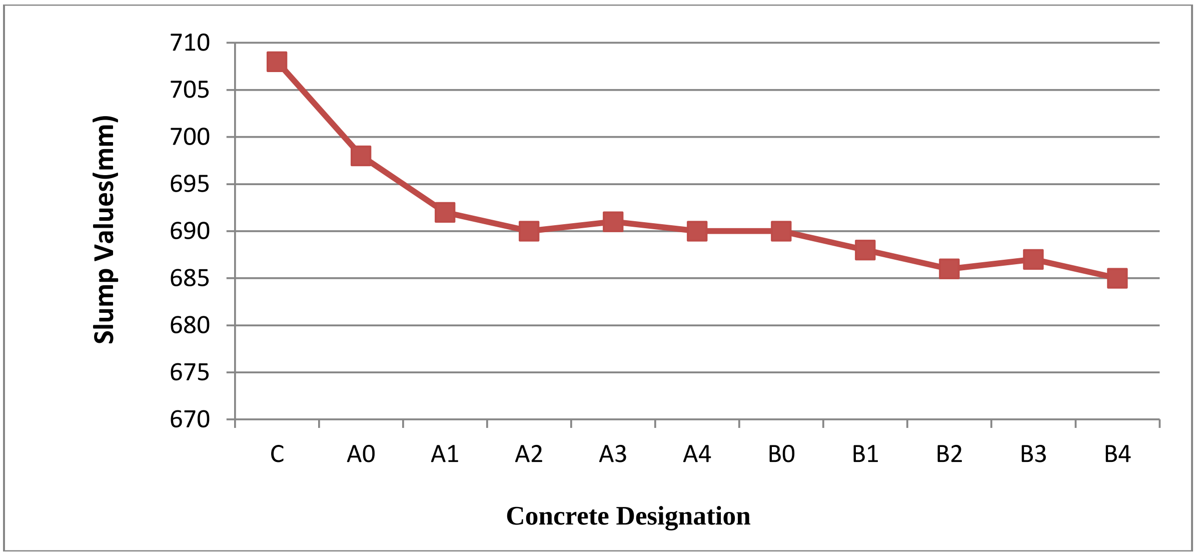

Fig 1 Slump Flow

T500 time Test :

Table 5. T500 time

Sl. No	Concrete	Percentage replacement of		Designation	T 500 time s
		FA	RCP		
1	Conventional	0%	0%	C	5.56
2	FA & RCP SCC(with 10% FA)	10%	0%	A0	5.12
3		10%	25%	A1	5.09
4		10%	50%	A2	5.12
5		10%	75%	A3	4.95
6		10%	100%	A4	4.93
7	FA &RCP SCC(with20% FA)	20%	0%	B0	4.89
8		20%	25%	B1	4.74
9		20%	50%	B2	4.76
10		20%	75%	B3	4.66
11		20%	100%	B4	4.57

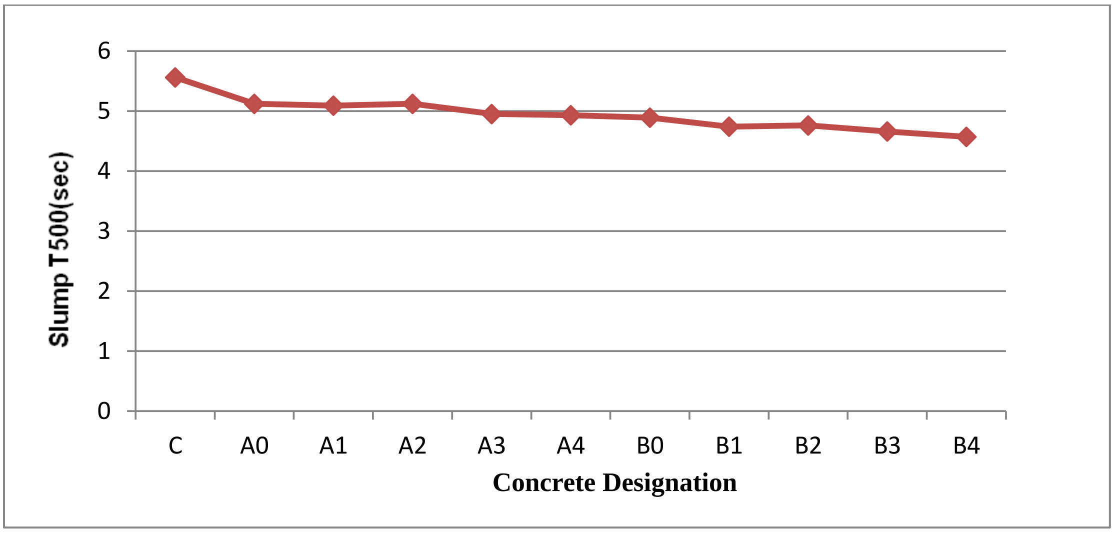

Fig 2 T500 time

Filling Ability (V-Funnel):

Table 6. V-Funnel Values

Sl. No	Concrete	Percentage replacement of		Designation	V-Funnel test Values in sec
		FA	RCP		
1	Conventional	0%	0%	C	8.96
2	FA & RCP SCC(with 10% FA)	10%	0%	A0	9.23
3		10%	25%	A1	9.56
4		10%	50%	A2	9.65
5		10%	75%	A3	9.52
6		10%	100%	A4	9.48
7	FA &RCP SCC(with20% FA)	20%	0%	B0	9.79
8		20%	25%	B1	9.86
9		20%	50%	B2	9.96
10		20%	75%	B3	10.15
11		20%	100%	B4	10.00

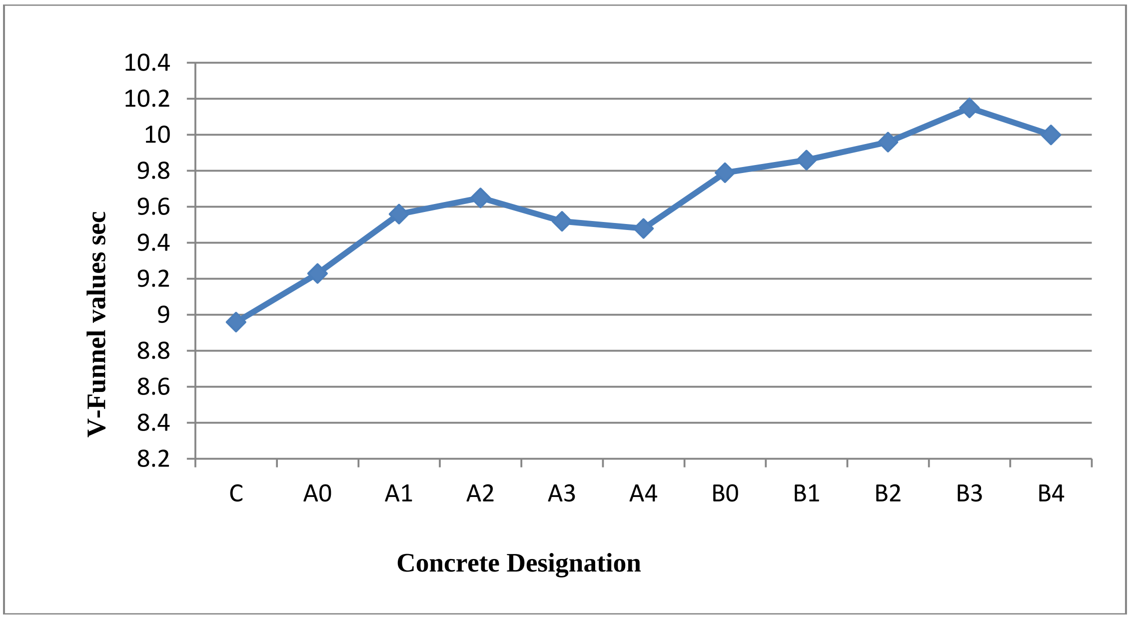

Fig 3 V Funnel Values

Passing ability (L-Box):

Table 7. L-Box Values

Sl. No	Concrete	Percentage replacement of FA	Percentage replacement of RCP	Designation	H1 in cm	H2 in cm	H2/H1 Ratio
1	Conventional	0%	0%	C	9.2	8.6	0.93
2	FA & RCP SCC(with 10% FA)	10%	0%	A0	9.3	8.5	0.91
3		10%	25%	A1	9.4	8.4	0.89
4		10%	50%	A2	9.4	8.3	0.88
5		10%	75%	A3	9.2	8.2	0.88
		10%	100%	A4	8.9	8.1	0.91
8	FA &RCP SCC(with20% FA)	20%	0%	B0	9.3	8.1	0.87
9		20%	25%	B1	9.2	8.0	0.86
10		20%	50%	B2	9.0	7.9	0.85
		20%	75%	B3	9.0	7.8	0.84
11		20%	100%	B4	8.9	7.8	0.88

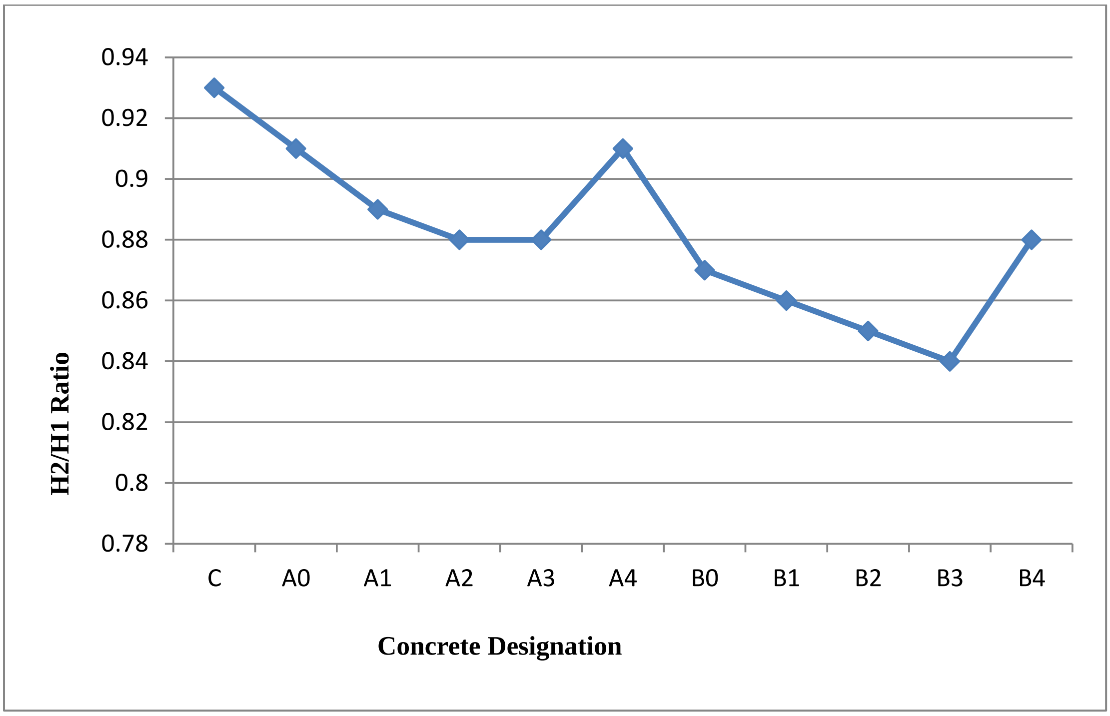

Fig 4 H2/HI Values

Compressive Strength: The test results of compressive strength of M50 grade FA, RCP Self compacting concrete and conventional Self compacting concrete for different curing periods of 28 and 56 days. The compressive strength of concrete of standard cube size 150mmx150mmx150mm is calculated using the formula

f=P/A

Where, f= Compressive strength of concrete in N/mm2

P= Ultimate load resisted by concrete in Newton's

A= Cross section area of cube specimen in mm^2

Table 8. Compressive strength of conventional SCC mix (C) & 10 % FA with four different replacement of RCP with respect to different curing periods

Sl.No	Concrete	Percentage replacement of		Designation	Compressive strength in N/mm2 for different curing Period	
		FA	RCP		28days	56 days
1	Conventional	0%	0%	C	54.31	59.14
2	FA & RCP SCC(with 10% FA)	10%	0%	A0	41.93	43.52
3		10%	25%	A1	40.93	42.35
4		10%	50%	A2	42.52	47.14
5		10%	75%	A3	40.15	45.12
6		10%	100%	A4	40.13	45.10

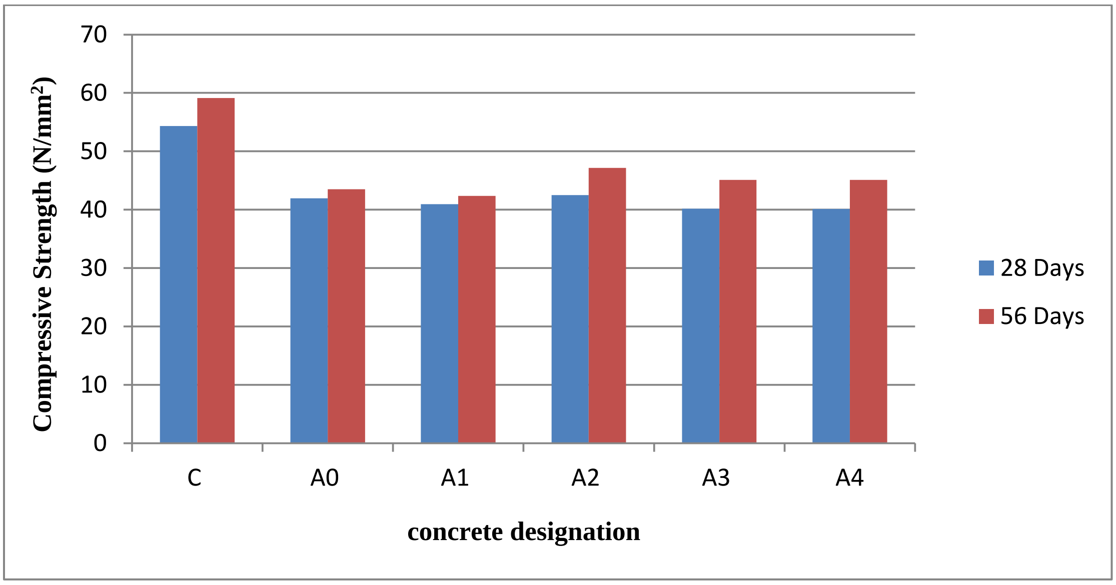

Fig 5 Comparison of Compressive strength for Table No 8

Table 9. Compressive strength of conventional SCC mix (C) & 20 % FA with four different replacement of RCP with respect to different curing periods.

Sl.No	Concrete	Percentage replacement of		Designation	Compressive strength in N/mm2 for different curing Period	
		FA	RCP		28days	56 days
1	Conventional	0%	0%	C	54.31	59.14
2	FA & RCP SCC(with 20% FA)	20%	0%	B0	40.38	45.40
3		20%	25%	B1	37.92	42.15
4		20%	50%	B2	39.20	44.12
5		20%	75%	B3	33.48	38.52
6		20%	100%	B4	33.27	38.43

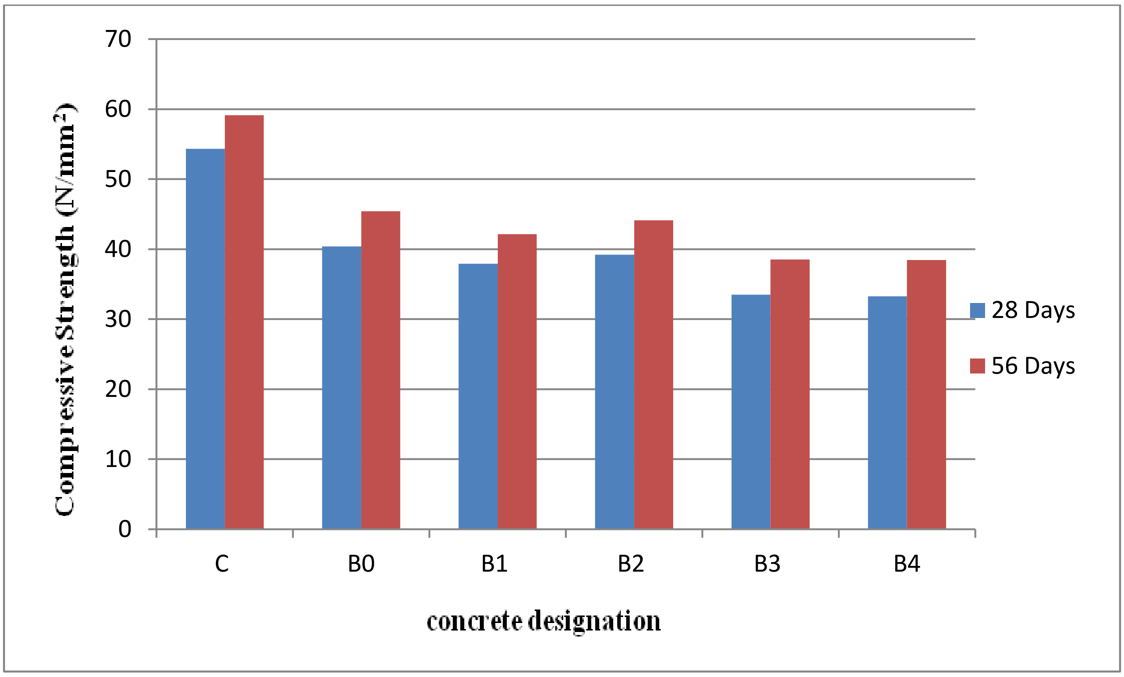

Fig 6 Comparison of Compressive strength for Table No 9

Split Tensile Strength: The test results of split tensile strength of M50 Grade concrete Cylinder of standard size 150mm Diameter and 300mm long cylinder specimen of RHA& RCP self compacting concrete and Conventional Concrete for different curing periods of 28 and 56 days are tabulated in Table 10.

The split tensile strength of concrete is given by the formula

FCS =2P/ΠDL N/mm^2

Where P= Failure loads of specimen in N

D= Diameter of the cylinder in mm

L = Length of the cylinder in mm

FCS= Fracture Strength N/mm^2

Table 10. Split tensile strength of conventional SCC mix (C) & 10 % FA with four different replacement of RCP with respect to different curing periods

Sl.No	Concrete	Percentage replacement of		Designation	Split Tensile strength in N/mm^2 for different curing Period	
		FA	RCP		28days	56 days
1	Conventional	0%	0%	C	3.91	4.03
2	FA & RCP SCC(with 10% FA)	10%	0%	A0	3.52	3.85
3		10%	25%	A1	3.30	3.55
4		10%	50%	A2	3.66	3.93
5		10%	75%	A3	3.06	3.32
6		10%	100%	A4	3.03	3.30

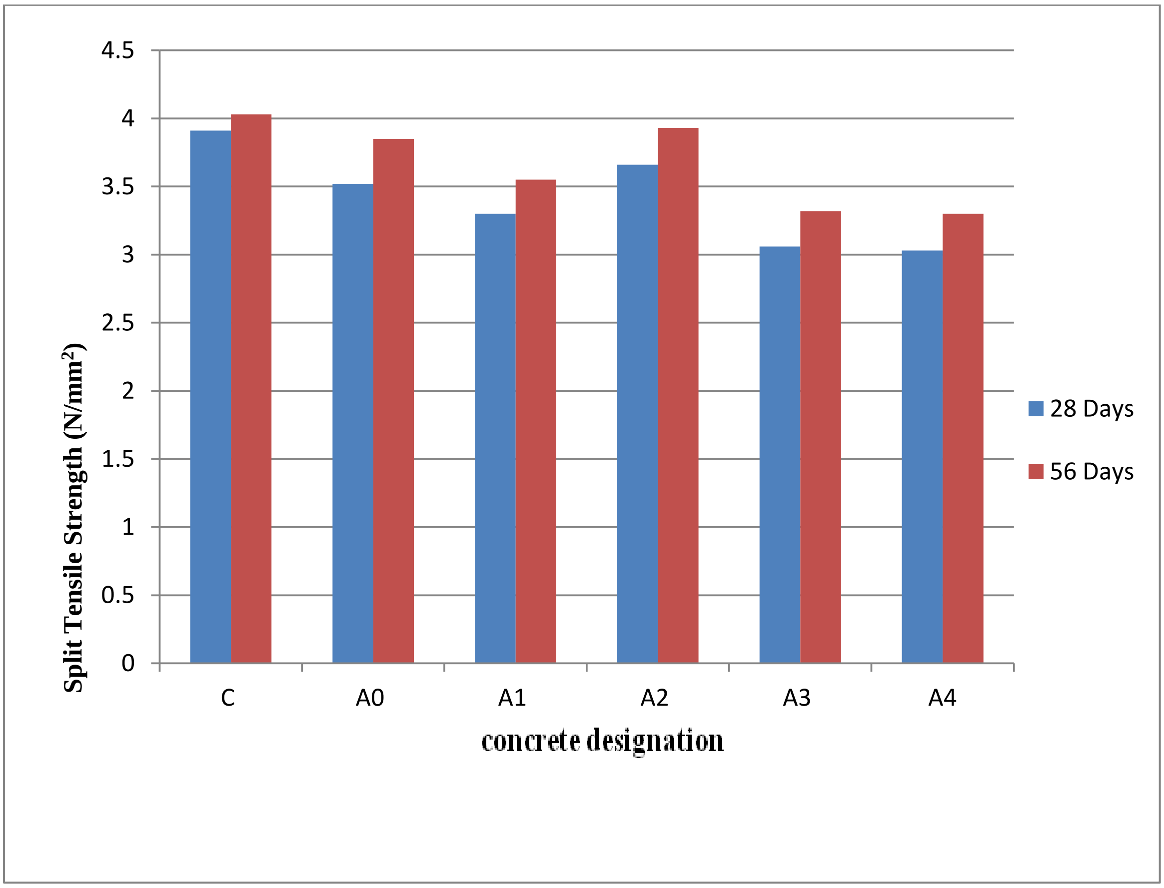

Fig 7 Comparison of Split tensile strength for Table No 10

Table 11. Split tensile strength of conventional SCC mix (C) & 20 % FA with four different replacement of RCP with respect to different curing periods.

Sl.No	Concrete	Percentage replacement of		Designation	Split Tensile strength in N/mm^2 for different curing Period	
		FA	RCP		28days	56 days
1	Conventional	0%	0%	C	3.91	4.03
2	FA & RCP SCC(with 20% FA)	20%	0%	A0	3.15	3.55
3		20%	25%	A1	2.98	3.35
4		20%	50%	A2	3.66	3.93
5		20%	75%	A3	2.73	3.32
6		20%	100%	A4	2.51	3.13

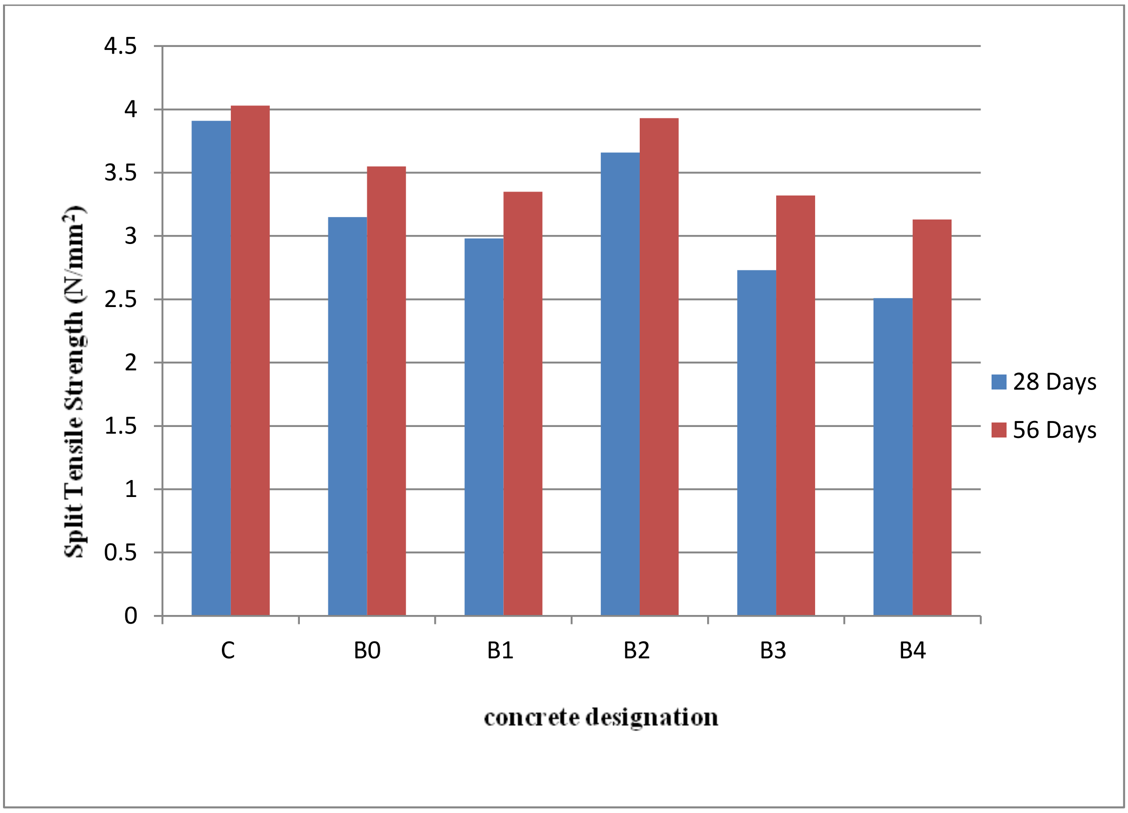

Fig 8 Comparison of Split tensile strength for Table No 11

Flexural Strength: The test results of flexural strength of prism of M50 FA, RCP SCC and conventional SCC for different curing periods of 28 & 56days are tabulated and the flexural strength of concrete, prism of standard size 100x100x500mm specimen is given by the formula.

$$f_f = PL/bd^2$$

Where, P = Failure load of specimen in N
b = Breadth of the prism in mm
d = Depth of the prism in mm
L = Length of the prism in mm

Table 12. Flexural strength of conventional SCC mix (C) & 10 % RHA with four different replacement of RCP with respect to different curing periods

Sl.No	Concrete	Percentage replacement of		Designation	Flexure strength in N/mm² for different curing Period	
		FA	RCP		28days	56 days
1	Conventional	0%	0%	C	7.21	8.96
2	FA & RCP SCC(with 10% FA)	10%	0%	A0	7.10	8.14
3		10%	25%	A1	6.17	7.70
4		10%	50%	A2	7.25	8.30
5		10%	75%	A3	5.93	7.36
6		10%	100%	A4	5.43	7.10

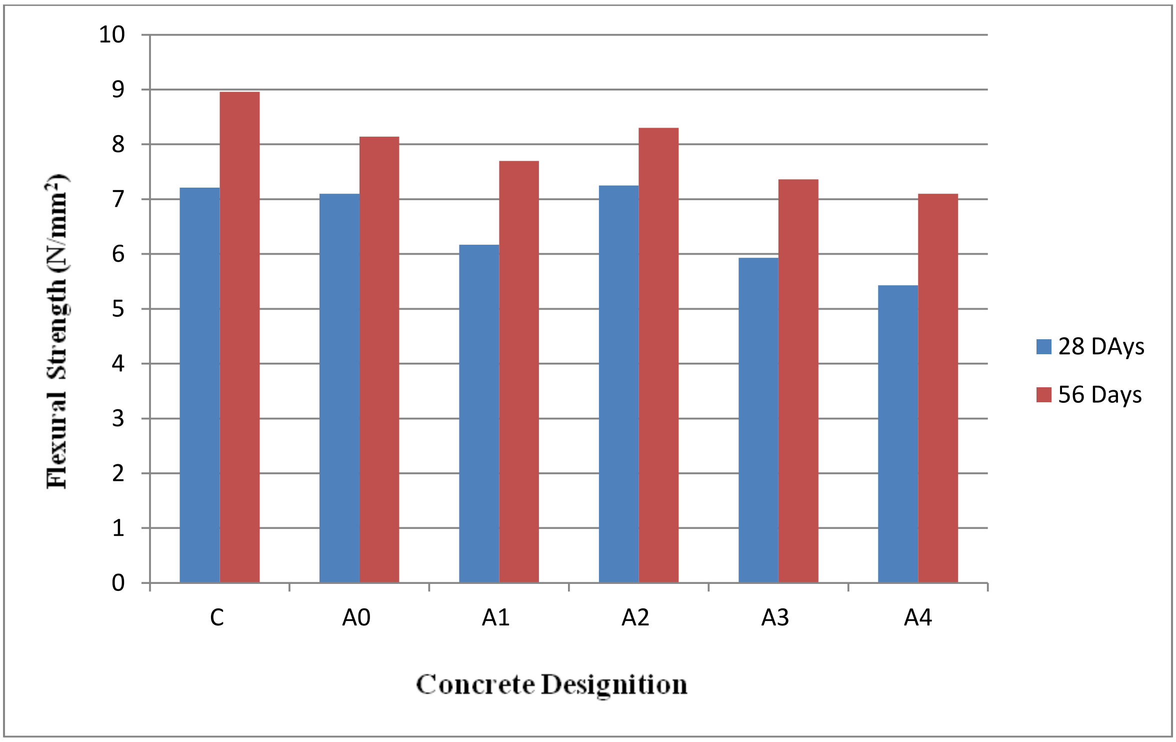

Fig 9 Comparison of Flexure strength for Table No 12

Table 13. Flexural strength of conventional SCC mix (C) & 20 % FA with four different replacement of RCP with respect to different curing periods

Sl.No	**Concrete**	**Percentage replacement of**		**Designation**	**Flexure strength in N/mm^2 for different curing Period**	
		FA	RCP		28days	56 days
1	Conventional	0%	0%	C	7.21	8.96
2	FA & RCP SCC(with 20% FA)	20%	0%	B0	6.05	7.65
3		20%	25%	B1	6.01	6.96
4		20%	50%	B2	6.56	7.53
5		20%	75%	B3	5.66	6.23
6		20%	100%	B4	5.13	6.10

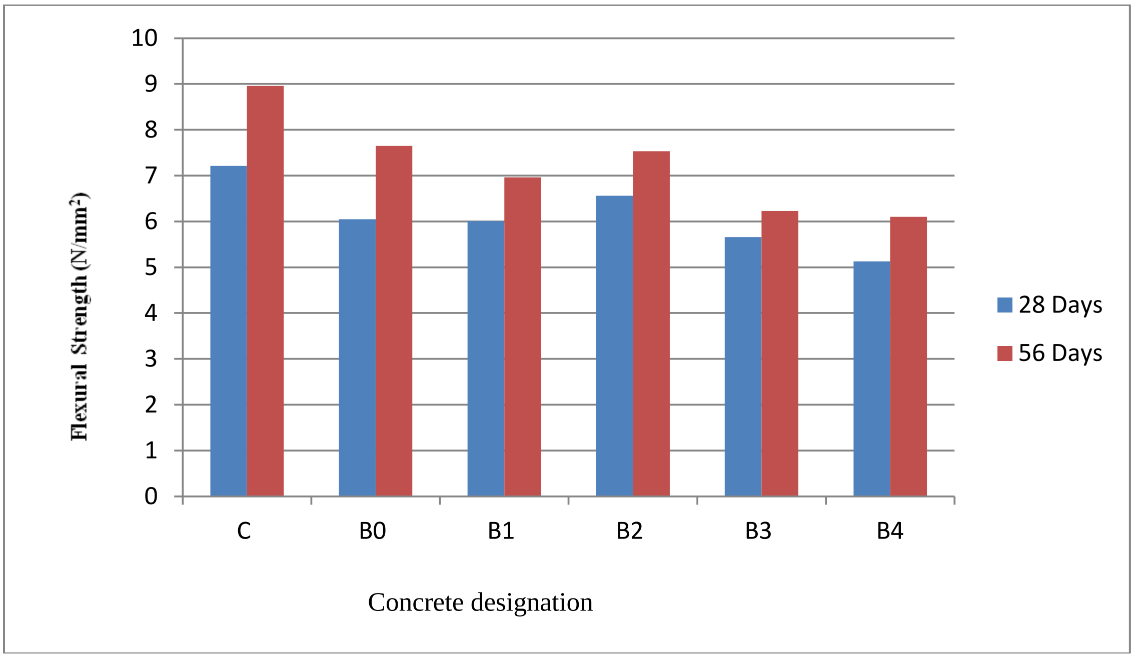

Fig 10 Comparison of Flexure strength for Table No 13

VI. CONCLUSION

This chapter summarizes the assessments and findings of Conventional SCC and FA & RCP SCC with respect to fresh properties of concrete (workability i.e., filling ability, passing ability, segregation resistance) and hardened properties of concrete (compressive strength, split tensile strength, flexural strength) for different levels of replacement of FA (10% & 20%) and RCP (0% ,25%, 50%, 75%,100%).

The hardened properties of concrete such as Compressive strength, Split tensile strength and flexural strength of SCCs has been made for different curing periods of 28 and 56 days.

The conclusions are based on the objectives of the research.

FA contributes in the reduction of agricultural waste that is the main cause of environmental problems in agricultural countries. On the other hand, it is an approach to improve the quality of concrete without using costly additives such as silica fume, GGBS etc.

- **Due to presence of FA in SCC along with RCP also the required strength of SCC is obtained after 56 days of** curing unlike normal concrete which attains the strength at 28days due to the reason that FA is to regulate the cement content so as to reduce heat of hydration. When heat of hydration is reduced strength development at early age is also reduced.

- The presence of FA reduces the slump, with the increase in quantity of FA in SCC's the reduction in slump also decreases. The addition of RCP along with FA further reduces the slump (From Table No. 4). This could be due the absorption of porous structure of FA and also due to high percentage of fines in both FA & RCP it goes to shrinkage.

- The replacement of 10% & 20% FA has more influence in reduction of compressive strength, split tensile strength, flexural strength compared to RCP. However the SCC with FA along with RCP further reduces the strength (From Table No. 7.5 &7.6).these could be due to that FA does not act as cement replacement because of its coarse particle size SCC (C).

- 50% replacement of RCP was performed better than the other proportion. So we can recommend that instead of using only sand, replacement should be used along with sand. We tried 100% replacement of RCP, which shrieked due to more fines.

- The SCC with replacement level of 10% or 20 % FA & RCP of 50% (A2&B2) performs better than the other proportions of FA & RCP SCC. and low reactivity.

- The percentage reduction of strength of SCC with 10% & 20 % replacement FA only showed poor results, when compared to additional RCP (25%, 50%,75% and 100%) along with 10% and 20% FA.

- Hence we recommended SCC with RCP for the replacement sand in proportion of 50% along with FA (10%&20%) instead of using SCC with only sand to get an economical SCC which will yield almost equivalent strength as that of conventional

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