EXPERIMENTAL STUDY OF RECYCLED AGGREGATE WITH SILICA FUME ON CONCRETE

Shubhasree V
Assistant Professor,
Department of Construction Technology and Management,The Oxford Engineering College of Engineering
Bangalore, Karnataka, India,

Abstract: The amount of recycled aggregates produced was increased day by day leading to environmental affects. The disposal of the recycled aggregate is uneconomical and can be utilized in the construction activities. In this paper an attempt has been done to find the efficiency of replacing coarse aggregate with recycled aggregates. The influence of combination of silica fume with recycled aggregates on concrete for M45 grade with 0.4 W/C ratio and 0.75% superplasticizer by weight of the cement. Percentage of silica fume is varied as 25%, 30%, 35% and 40% by weight of natural aggregate and the silica fume by 10% and 20% by weight of cement to determine the fresh and hardened properties of the concrete. Compression, flexural, split tensile strength and modulus of elasticity tests are conducted to determine the influence of silica fume with recycled aggregates after 7, 28 and 56 days curing. Compressive strength of the concrete increases with increase in the amount of recycled aggregates up to 35% and then decreases with further increase in the amount of recycled aggregate. Optimum compressive strength of 72.64 Mpa and optimum flexural strength of 5.32 Mpa was obtained at 10% of silica fume and 35% of recycled aggregate. Modulus of elasticity of 34611 Mpa was achieved at 10% silica fume and 35% recycled aggregate.

Index Terms: Silica fume (SF), Recycled coarse aggregate (RCA), natural aggregate,Replacing, Compressive, Flexural, split tensile strength, modulus of elasticity (E).

1. INTRODUCTION

Concrete is far most used as a construction material, commonly from combination of broken stone, sand, binding material and water which can be poured into moulds which forms a stone like mass on hardening. It is the most important building material which used in various forms of construction such as reinforced concrete that is used to make building columns and decks for high rise building due to its longer life, low maintenance cost, strength and better performance. It is often used for residential driveways, house foundations, walls, pavements and other building infrastructures. Due to the industrialization, urbanization growth. Due to the development of infrastructure large quantities of construction material are used which leads to depletion of quantity of natural aggregates. This leads to high awareness of environmental conservation and increasing the cost of natural aggregate in whole world.

Commonly, structural detoration, development of city, extension of traffic directions and day by day rising traffic weight, environmental calamities (seismic activity, fire and overflow) leads to the construction and demolition wastes. Around 850 million tons of building and crushed derbies produced in the EU annually, which represents 31% of overall waste production (Parkesh and Modhera, 2011). In that, construction wastes are 20 to 30 times less than demolition wastes.Aggregate producing from the processing of inorganic material earlier used in construction and mainly comprising of crushed concrete is washed and recycled as aggregate in the production of additional concrete.

Now days, a general technique is applied to enhance the properties of concrete by alteration of the interfacial transition zone between the aggregate and bulk density of concrete by silica fume. It is extremely fine pozolonic material comprised of amorphous silica formed by electric arc furnaces as a by-product of elemental silicon or alloy of Ferro silicon.It Silica fume is also known as micro silica, condensed and volatilized SF or silica dust. It is used to enhance the mechanical properties to excessive level by lime consuming action, pore size distribution lesser, heat of hydration lower , minor porosity, permeability and bleeding. Fig 3 shows the flow chart of basic effect of micro silica in concrete.

II. MATERIALS USED

2.1 cement

Ordinary Portland cement of 43 grade with cement content 410 kg/m^3 was used in this work. The cement was stored in bags and kept under minimum exposure from humidity. Light grey colour cement free from any hard lumps was used shown in fig1.

Fig 1.Cement

Table 2.1 Physical Properties of Cement

Sl. No.	Properties	Test Results	Requirements as per IS:8112-1989
1	Specific gravity	3.02	3-3.15
2	Normal Consistency	31%	26%-33%
3	Initial setting time	65 min	>30 minutes
4	Final setting time	575 min	<600 minutes
5	Fineness (Blain's Air Permeability)	320	>225
6	Compressive strength Mpa 3, 7 days and 28 days	24.5	>23
		37	>33
		45	>43

2.2 silica fume

silica fume is the by-product of silicon or Ferro silicon which is produced in the electric arc furnace. Densified dark grey colour silica fume collected from Manjeshwar Traders, Mangalore was usedshown in fig2. Physical properties of silica fumes given in the Table 2.2.

Table 2.2 Physical Properties of Silica Fume

Sl. No	Properties	Results
1	Colour	Grey colour
2	Specific Gravity	2.13

Fig 2.Silica Fume

2.3 Fine Aggregate

Locally available river sand which is passing from 4.75 mm sieve size is used in this study. Fine aggregates physical properties are given in the Table 2.3

Table 2.3 Properties of fine aggregate

Sl. No	Tests	Results	Test conforming to
1	Specific gravity	2.65	IS 2386 (part-III)-1963
2	Water absorption, %	1.0	

2.4 Coarse Aggregate

Natural coarse aggregate (NCA), locally available, crushed stone having 20mm down size and RCA from tested concrete specimen waste crushed in to 20mm down size with the help of jaw crusher were used in this study. Physical properties of NCA and RCA are listed in the Table 2.4

Table 2.4 Properties of coarse aggregate

Sl. No	Tests	Results		Test conforming to
		NCA	RCA	
1	Specific gravity	2.7	2.45	IS 2386 (part-III)-1963
2	Water absorption, %	0.48	1.43	
3	Aggregate crushing	21.29	27.26	IS 2386 (part-IV)-1963
4	Aggregate impact value,	29.35	34.03	
5	Flakiness and Elongation Index	27%	26%	IS 2386(Part-1)-1999

2.5 Water

Water plays an important role in concrete during mixing, placing, compacting and curing of the concrete specimen to achieve the strength of the concrete. Increasing the quality of water can enhance the strength of the concrete. Hence potable water was used in this study.

2.6 Super Plasticizer

Super plasticizer is used to increase the workability of the concrete. Conplast SP 430 conforming IS 9103-1999 was used in this study.

III METHODOLOGY

Concrete mix was designed for 1:1.68:2.79 ratio with M45grade for the experimental study as per the code IS 10262-2009 with water cement ratio as 0.4. Super plasticizer is added to increase the workability of the concrete and is added by 0.75% by the weight of cement with 100mm slump. Recycled aggregate is replaced by 25%, 30%, 35% and 40% with natural aggregate and silica fume is partially replaced by 10% and 20% by weight of cement.

To check the mechanical properties of the concrete such that density test, compression, flexural, split tensile, modulus of elasticity, various specimens are casted by Cement, silica fume, fine and coarse aggregates, water and super plasticizer are weighed according to the mix proportion 1:168:2.79:0.4 corresponding to M45grade concrete.these are shown in fig 3.1 and fig3.2. Natural aggregate and recycled aggregate are added to the wet drum and 25% of water and super plasticizer are also added. Then fine aggregate, cement and silica fume are added with remaining water and super plasticizer is poured in to the wet drum and homogenously mixed. For every mix slump cone test was carried out to measure the workability. This wet mix is poured in to the moulds and compacted with the help of mechanical vibrator. Demoulding done after 24 hours and kept curing for 7, 28, 56 days and specimens are tested. Water immersion type of curing was adopted in this study.To check workability of concrete slump cone test was used.

Fig 3.1material collection,mixing , casting, curing

Fig 3.2 slump test, compression test, flexural test,split tensile test, modulus of elasticity

IV RESULT AND DISSCUSSION

4.1 Effects of Silica Fume (SF) on Workability of Concrete

The slump cone test is conducted to ascertain the workability of concrete. Fig 4.1 explains the graphical representation of effect of silica fume on workability of concrete. It shows that higher the percentage of silica fume decreases the workability of concrete. Silica fume having higher surface area which absorbs more water. The slump value of the control mix higher than the other mixes.

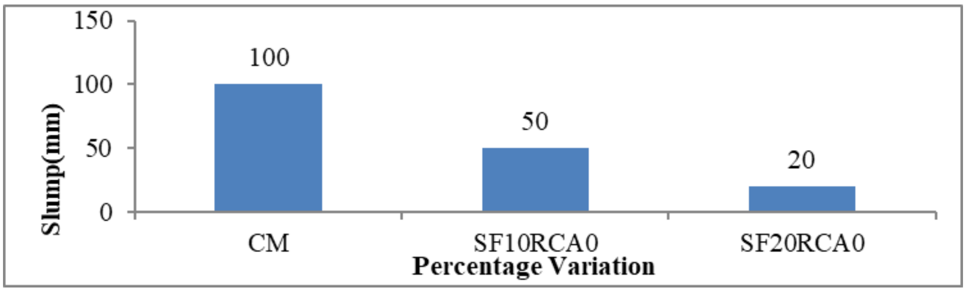

Fig 4.1Effects of Silica Fume on Workability of Concrete

4.2 Effect of RCA on Workability of Concrete

From the Fig 4.2 it is seen that workability of recycled aggregate decreases with increase in percentage of RCA with constant water cement ratio 0.4, due to presence of adhered mortar on the surface of recycled aggregate and micro cracks in RCA. Slump value of control mix was 100mm that was higher than the varying percentage of recycled aggregate.

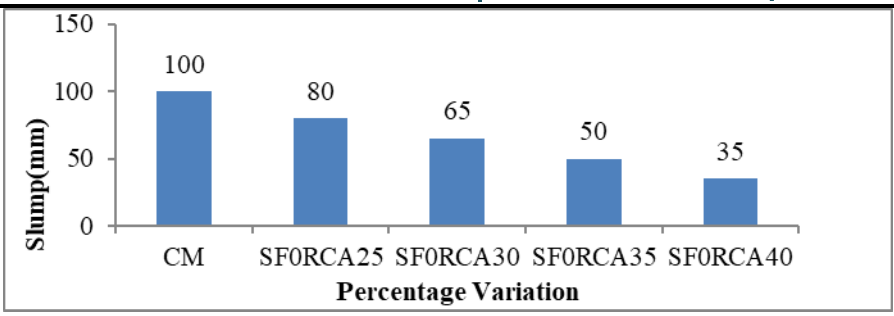

Fig 4.2 Effect of Recycled Coarse Aggregate (RCA) on Workability of Concrete

4.3 Effect of Addition of Silica Fume on RCA Concrete

From Fig 4.3 and 4.4 it is seen that workability of concrete is decreases with higher percentage of silica fume and recycled aggregate. It is due to fineness of silica fume, it was1/100 times more than the cement. Hence water absorption increases. Workability decreases 100mm to 5mm.

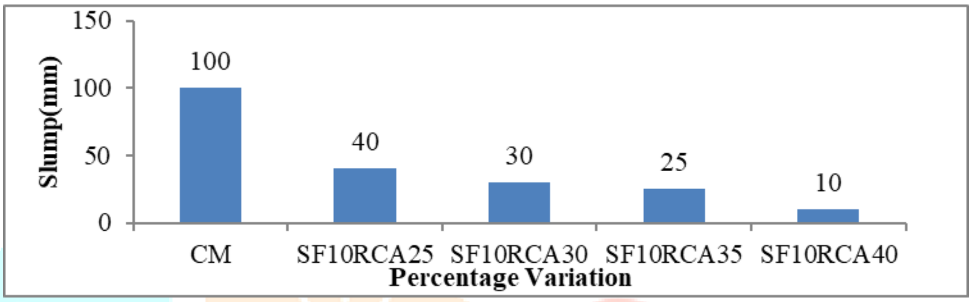

Fig 4.3 Effect of 10% SF with Varying Percentage of RCA on Workability of Concrete

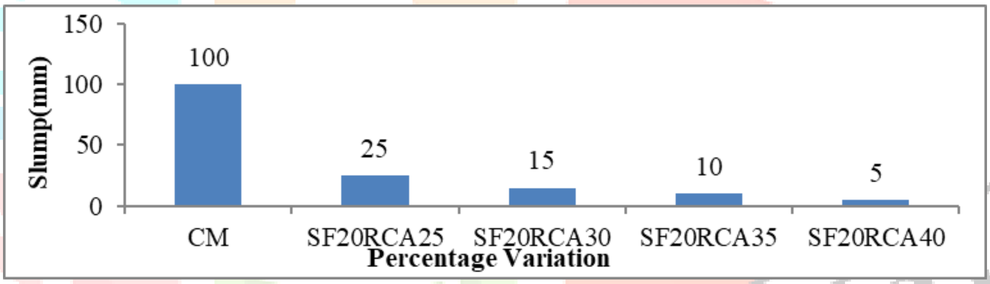

Fig 4.4 Effect of 20% SF and Varying Percentage of RCA on Workability of Concrete

4.4 Effect of Silica Fume on Density of Concrete

Normal concrete density is about 2400 kg/m3. Density influences the strength of concrete and also gives the information about compaction and particle packing. Fig 4.5 shows that influence of silica fume on density of concrete. Addition of 10% of silica fume increases density to 0.6%, 20% increment of silica fume density reduced to 4.4% this is mainly due to silica fume act as a filler material which fills the pores.

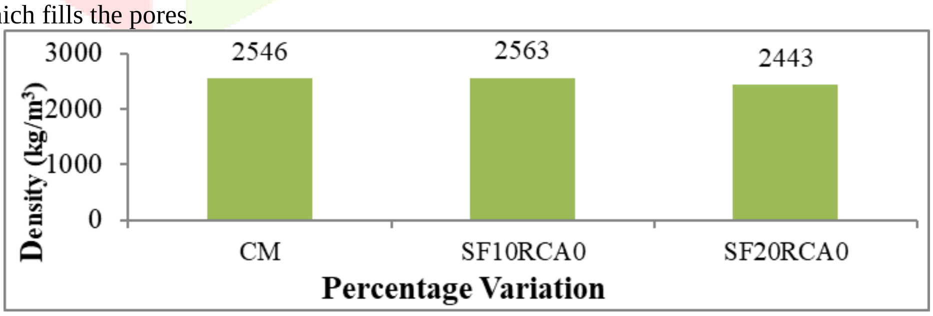

Fig 4.5 Effect of Silica Fume on Density of Concrete

4.5 Effect of RCA on Density of Concrete

From Fig4.6it is observed that when percentage of recycled aggregate increases density decreases up to 4.24% with 35% of RCA compared to control mix. Due adhered mortar on the RCA there will be decrease in density.

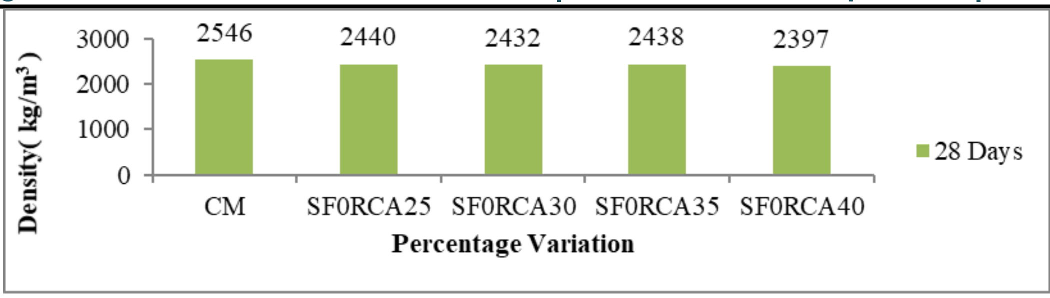

Fig 4.6 Effect of Recycled Coarse Aggregate on Density of Concrete

4.6 Effect of Addition of Silica Fume on RCA Concrete

From the Fig 4.7 and it was clearly observed that density of concrete is increased at 35 % recycled aggregate with 10% silica fume in the range of 0.5% compared to control mix. This is due to action of filler materials which fills the pores space of the concrete. Fig 4.8 shows density of concrete decreases at 35% RCA with 20% silica fume.

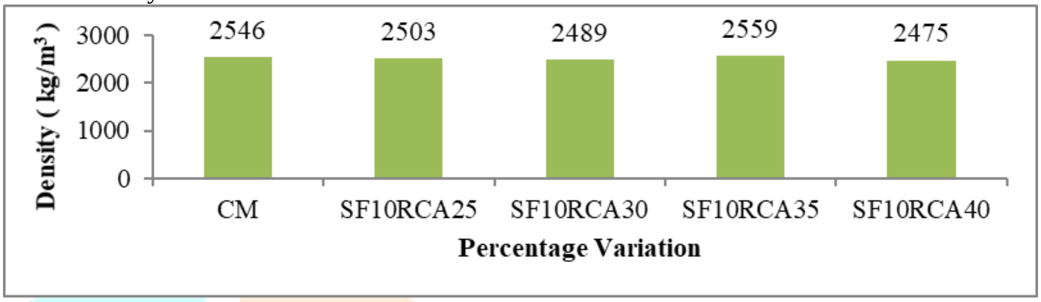

Fig 4.7 Effect of 10% SF with recycled aggregate on density of concrete

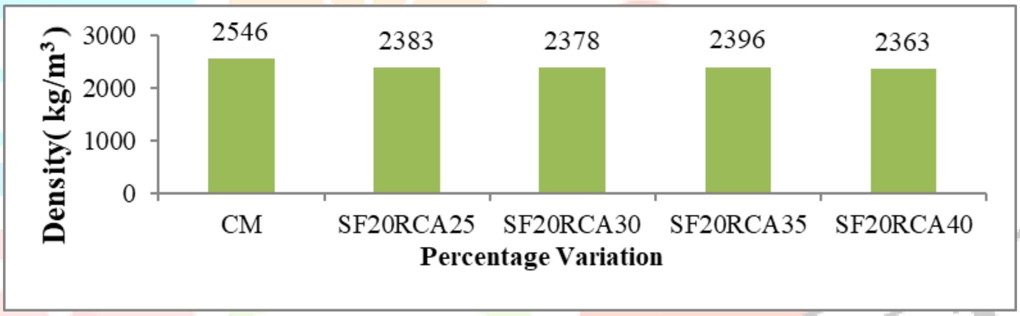

Fig 4.8 Effect of 20% silica fume with recycled aggregate on density of concrete

4.7 Effect of Silica Fume on Compressive Strength of Concrete

Fig 4.8 shows the effect of silica fume on compressive strength of concrete. 10% silica fume gives maximum strength than control mix on 28 days, such as 10 % more strength gives than control mix. Further increase in the silica fume decreases the strength than control mix. Because once the silica fume reaches its saturation state further reaction does not take place. Maximum strength obtained on 56 days was 70.67Mpa, which14.33% more than the control mix.

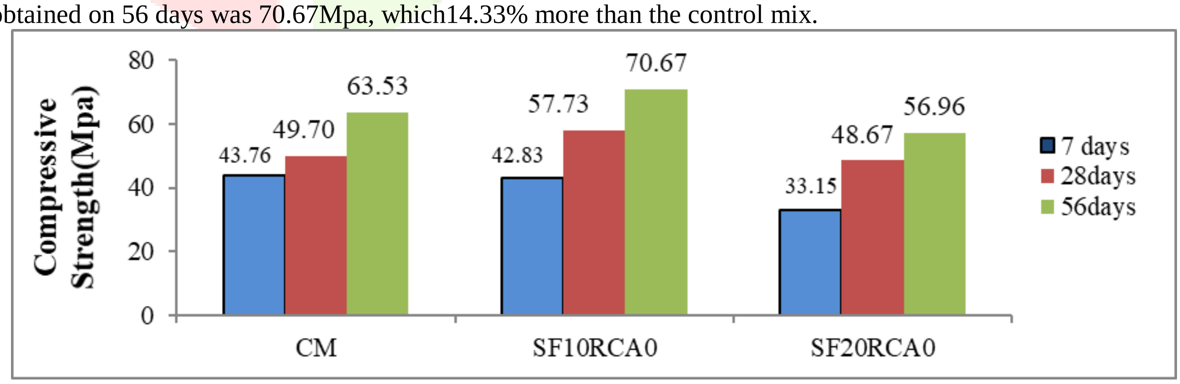

Fig 4.9 Effect of Silica Fume on Compressive Strength of Concrete

4.8 Compressive Strength of RCA on Concrete

Fig 4.10 represents the effect of recycled aggregate on compressive strength of concrete in 7, 28, 56 days. RCA strength was decreased up to 30% and suddenly increased at 35% further strength was decreased. But 13.85% strength was reduced compared to control mix for 56 days. Due to size, shape and adhered mortar in aggregate impart the strength of aggregate.

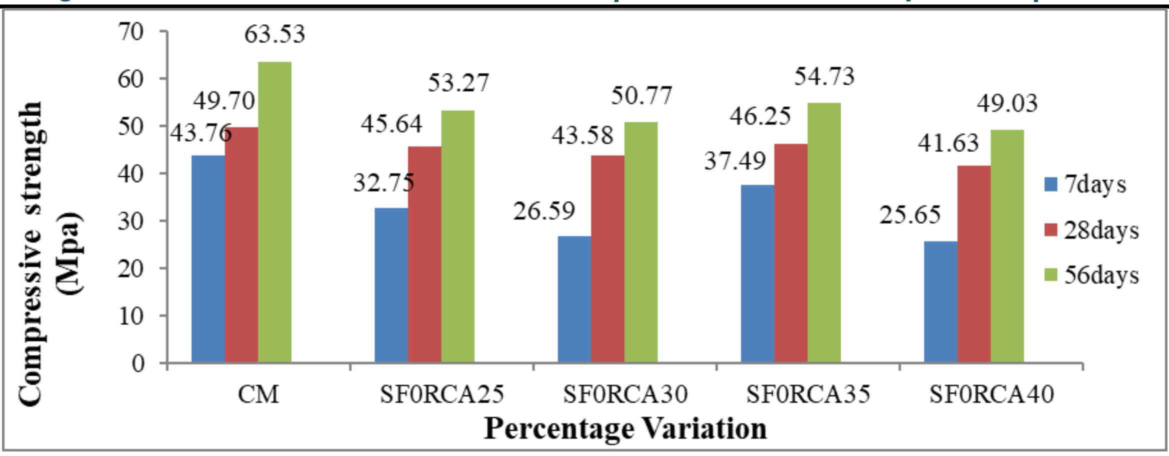

Fig 4.10 Compressive Strength of Recycled Aggregate on Concrete

4.9 Effect of Addition of Silica Fume on RCA Concrete

Fig 4.11 and 4.12 represents the effect of addition of silica fume on RCA concrete for 7, 28, 56 days of curing. It can be observed that by adding 10% of SF with 35% of RCA for 7, 28, 56 days strength was increased in the range of 2%, 24% and 14.33%compared to control mix. This may be due to silica fumes particle size less than 1µm so it act as the additional binding and enhance the compressive strength of concrete. Size and shape of the recycled aggregate impart the strength of concrete. Once silica fume reaches its saturation state further addition of silica fume does not affects the strength of concrete.

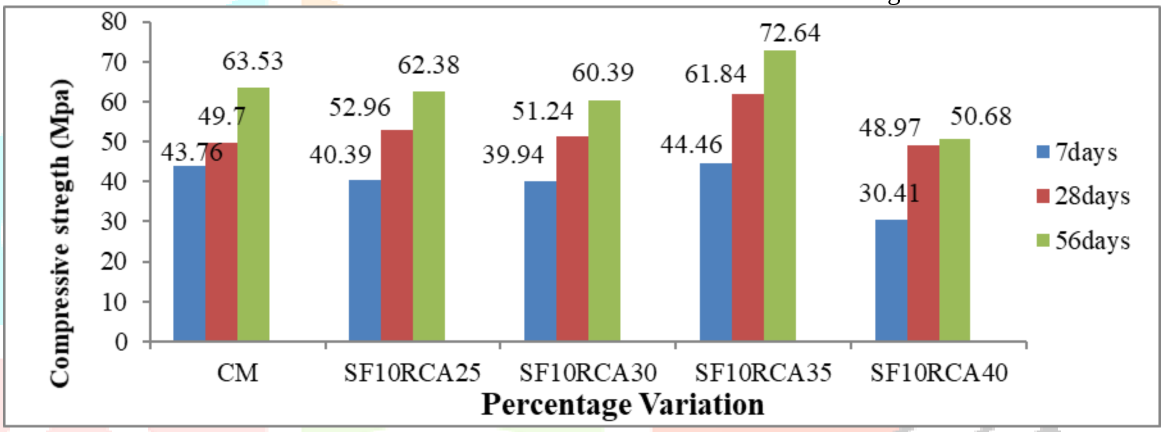

Fig 4.11 Effect of 10% SF with RCA on Compressive Strength of Concrete

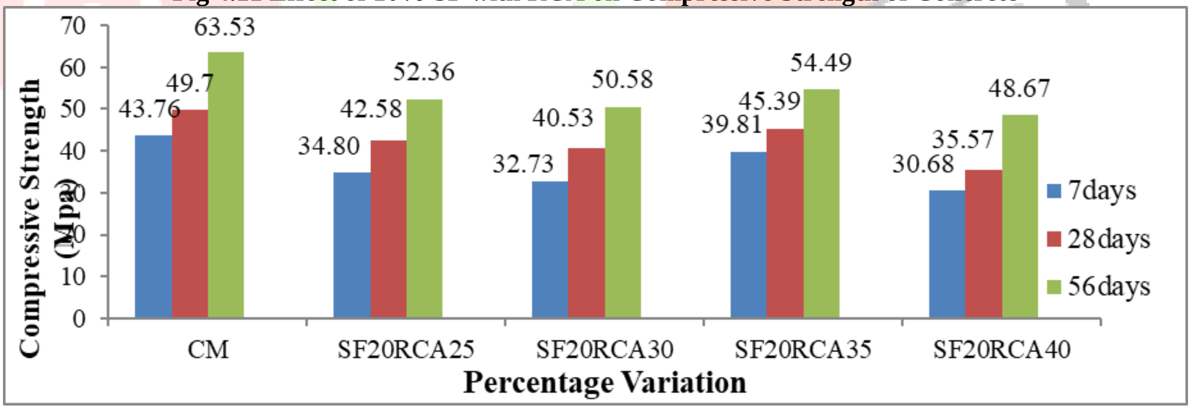

Fig 4.12 Effect of 20% SF with RCA on Compressive Strength of Concrete

4.10 Effect of SF and RCA on Flexural Strength of Concrete

Fig 4.13 explains the influence of SF and recycled aggregate on flexural strength of concrete in 28 days. From the graph it is clearly observed that 10% of silica fume improve the flexural strength of concrete than control mix in the range of 8.9%. Due to C-S-H gel formation by the silica fume causes the enhancement of strength of concrete. Further addition of silica fume decrease the flexural strength of concrete. Optimum flexural strength was achieved at 35% replacement of recycled aggregate with 10% of silica fume. 14.92% of strength was higher than control mix.

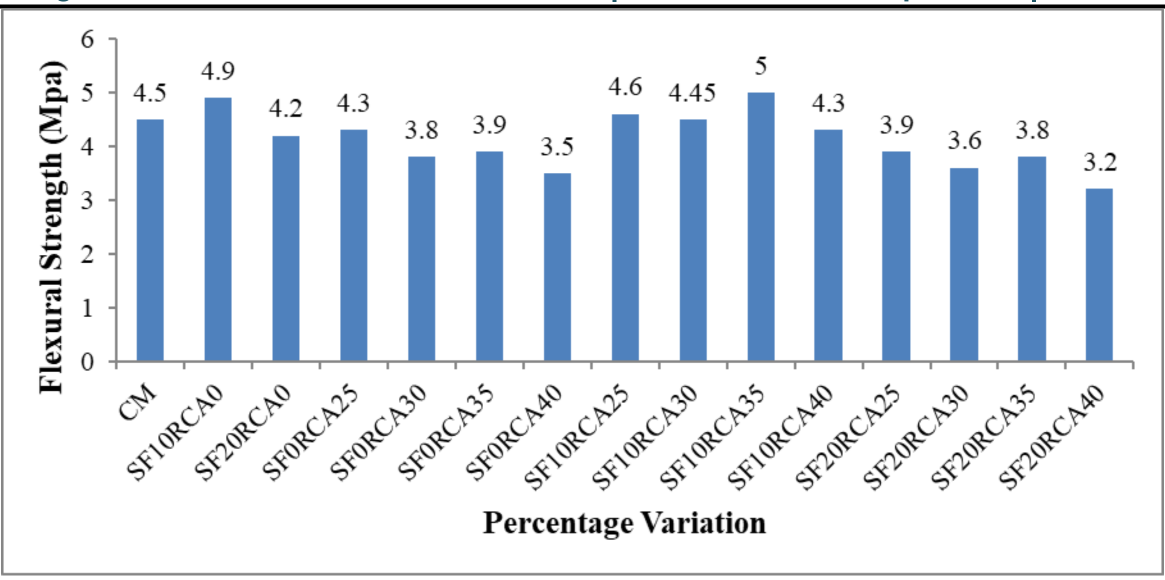

Fig 4.13 Effect of SF and Recycled Aggregate on Flexural Strength of Concrete

4.11 Effect of SF and RCA on Split Tensile Strength of Concrete

Fig 4.14 explains the influence of SF and recycled aggregate on split tensile strength of concrete for 28 days. From the graph it seen that tensile strength of concrete is increases when silica fumes is added to the concrete. Optimum percentage of silica fume is 10% and further increasing the percentage, the strength decreases. Recycled aggregate increases the split tensile strength up to 35% further suddenly decreasing the strength, but the strength is less than the control mix. Optimum strength is obtained when 10% of silica fume with 35% of recycled aggregate is replaced, and increased tensile strength of 9.69% was observed. This may be due to silica fumes particle size less than 1μm so it act as the additional binding and enhance the Split tensile strength of concrete.

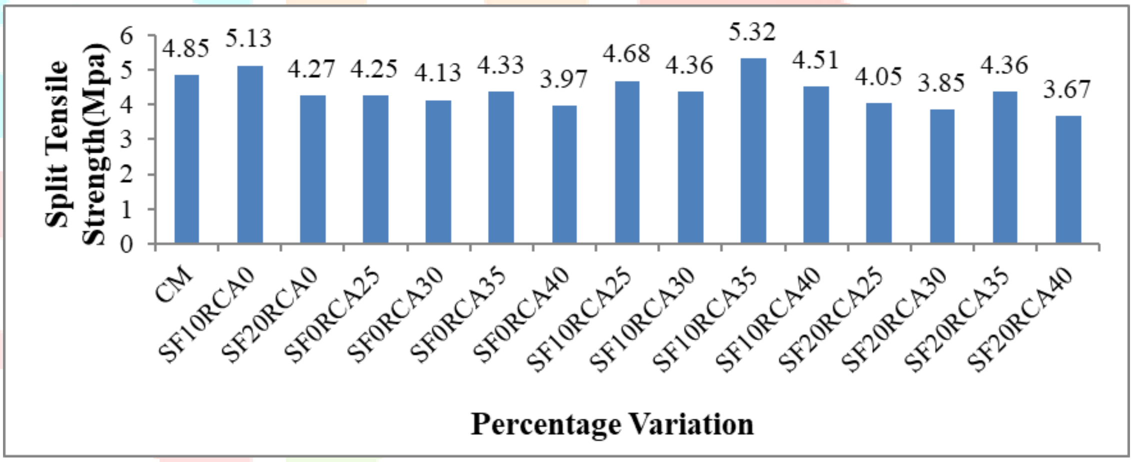

Fig 4.14 Effect of SF and RA on Split Tensile Strength of Concrete

4.12 Effect of SF with RCA on Modulus of Elasticity of Concrete(E)

Fig 4.15 represents the influence of SF and recycled aggregate on modulus elasticity of concrete on 28 days of curing. From the graph it is observed that 10% silica fume, E increased further increasing the percentage of silica fume, modulus of elasticity decreased. Optimum E value obtained at 10% of silica fume with 35% of recycled aggregate was16.86% compared to control mix.

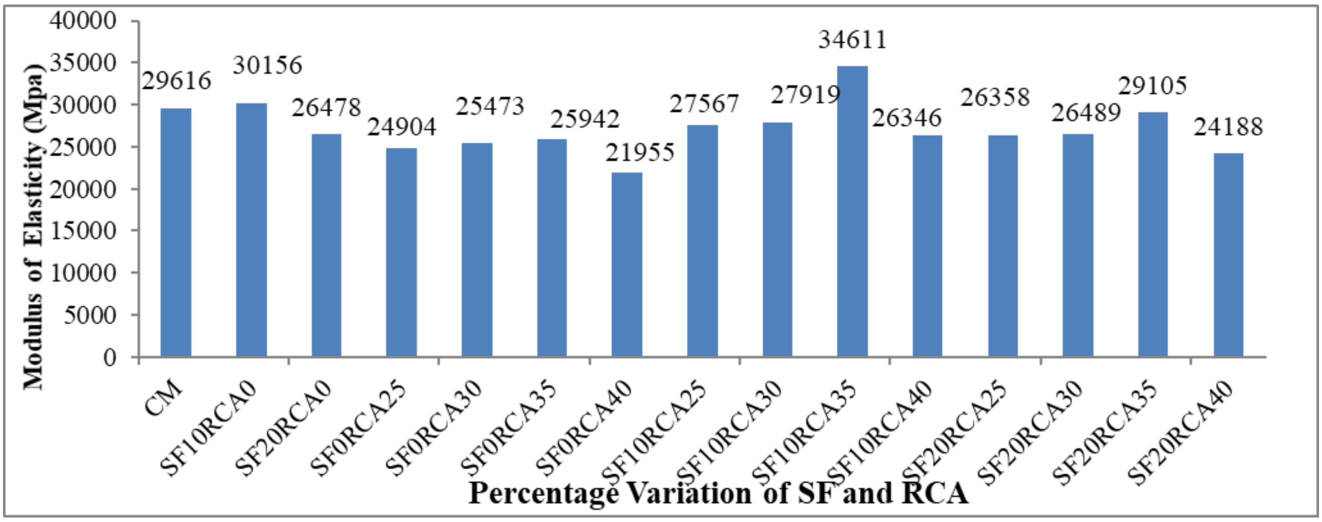

Fig 4.15 Effect of SF with Recycled Aggregate on Modulus of Elasticity of Concrete

V. CONCLUSIONS

1. The preliminary tests conducted for natural aggregate and recycled aggregate satisfied the standard specifications. The recycled aggregates have higher water absorption capacity (1.97%) compared to the natural aggregate.
2. The workability of the concrete decreases with increase in the amount of recycled aggregates which have higher water absorption due to the presence of mortar in it.
3. The workability of silica fume decreases with increases in the percentage of SF.
4. The compressive strength of recycled aggregate with SF increases up to a certain percentage and then the strength decreases slightly. The compressive strength of the concrete with 35% recycled aggregate and 10% silica fume is 72.64 Mpa which is found to be more than the normal concrete.
5. The flexural and the split tensile strength of concrete decreases with increase in the amount of silica fume and recycled aggregate. Optimum flexural strength of 5 Mpa and split tensile strength of 5.32 Mpa was achieved when 10% of silica fume is added to the concrete with 35% of recycled aggregate.
6. The modulus of elasticity of the concrete decreased with increase in the amount of silica fumes and varying percentage of recycled aggregate. The optimum value was found to be 34611Mpa, when 10% silica fume and 35% recycled aggregates are added.

REFERENCE

1. Amudhavalli, N.K., and Jeena, M. (2012) "Effect of Silica Fume on Strength and Durability Parameters of Concrete", International Journal of Engineering Sciences and Emerging Technologies, ISSN:2231, Volume 3, Issue1.
2. Bhatt, R.Y.V., and Akbari. (2015),"Behaviour of Recycled Aggregate in Blended Concrete with Micro Silica and Fly Ash", International Journal for scientific Research and Development,Vol.3 ,Issue 03.
3. Debabarata, P., and D.Dutta.(2013) " Influence of Silica Fume on Normal Concrete",International Journal of Engineering Research and Applications, Vol.3, Issue www.ijera.com
4. Dilip, k.s.r., amitava,s.(2012) "Effect of Partial Replacement of Cement by Silica Fume on Harden Concrete", International Journal of Emerging Technology and Advanced Engineering, ISSN 2250-2459, volume 2, issue 8 www.ijetae.com.
5. Parkhand, D.N., and Modhera,C.D. (2012)"Percentage variation of effect of silica fume and recycled aggregate concrete", International Journal of Advanced Engineering Research and studies, vol-1.
6. Faiz, A.M., and Mohammed, A.(2010) "Mechanical properties of Recycled Aggregate Concrete Incorporating Silica Fume" ,ISBM 9781-1-4507-14907-7 http://www.classie.info/proccedingd.htm
7. Faseyemi,V.(2012) "Investigations on Micro Silica(Silica Fume) As Partial Cement Replacement in Concrete", Global Journal of Researches in Engineering Civil and Structural Engineering , Volume 12, Issue 1, ISSN: 2249-4596.
8. Hyungu, G.(2011) " Processing and Properties of Recycled Aggregate concrete", Submitted in Partial Fulfilment of the Requirements for the degree of master of Science in Civil Engineering in the Graduate College of the University of Illinosisat Urbana- champaign.
9. Mirjana, M., Vlastimir, R., and Snezana, M. (2010) "Recycled Concrete as Aggregate for Structural Concrete Production" ,Sustainability, ISSN 2071- 1050. www.mdp.com/journal/sustainability .
10. Parekh, D.N., and Modhera, C.D(2011) "Assessment of Recycled Aggregate concrete" Journal of Engineering Research and Studies.divyaparekh@yahoo.com