International Journal of Science and Research (IJSR)
ISSN (Online): 2319-7064
Index Copernicus Value (2015): 78.96 | Impact Factor (2015): 6.391

Effect of Recycled Aggregate along with Glass Fiber and Fly Ash on Concrete Properties

J. Suneel[1], P. S. S. Anjaneya Babu[2]

[1]PG Student, Department Of Civil Engineering, Gudlavalleru Engineering College, India

[2]Assistant Professor, Department of Civil Engineering, Gudlavalleru Engineering College, Andhra Pradesh, India

Abstract: ***Waste arising from construction and demolition constitutes one of the largest waste streams within the developed and developing nations. The use of recycled coarse aggregate (RCA) and fly ash (FA) is one of the approaches towards this need. Use of RCA and FA in concrete can be useful for environmental protection and economical aspects. In this experimental study the natural coarse aggregate is replaced with recycled coarse aggregate at different percentage and the mechanical strength of concrete is tested. In addition the fly ash is introduced as replacement of Cement and also glass fibers are added to improve the quality of concrete and tensile strength. Cylinders and cubes are casted by replacing coarse aggregate with 0%, 25%, 50%, 75% and 100% recycled coarse aggregate. In addition 10% 20% & 25%of fly ash 0.05% 0.015% &0.025% glass fibers is introduced as replacement of Cement to improve the quality of concrete. Here the effect of replacement of fly ash and addition of glass fibers on the properties of recycled aggregate concrete is studied and compressive strength & split tensile strength is compared with normal concrete without fly ash. The target strength is achieved in compression at 20% replacement of fly ash, 0.015% addition of S-Glass fibers and in tension at 10% replacement of fly ash, 0.015% addition of S-Glass fibers.***

Keywords: Recycled aggregate, recycled coarse aggregate concrete, fly ash, Glass fiber, Compressive strength, Split tensile strength.

1. Introduction

Any construction activity requires several materials such as concrete, steel, brick, stone, glass, clay, mud, wood, and so on. However, the cement concrete remains the main construction material used in construction industries. For its suitability and adaptability with respect to the changing environment, the concrete must be such that it can conserve resources, protect the environment, economize and lead to proper utilization of energy. To achieve this, major emphasis must be laid on the use of wastes and byproducts in cement and concrete used for new constructions. The utilization of recycled aggregate is particularly very promising as 75 to 80 percent of concrete is made of aggregates. In order to reduce the usage of natural aggregate, recycled aggregate can be used as the replacement materials. As innumerous numbers of materials are used as replaced for natural aggregate, some of them are slag, power plant wastes, recycled concrete, mining and quarrying wastes, waste glass, incinerator residue, red mud, burnt clay, sawdust, combustor ash and foundry sand. These materials are generally from buildings, roads, bridges, and sometimes even from catastrophes, such as wars and earthquakes. which are now posing a serious problem of disposal in urban areas. This can easily be recycled as aggregate and used in concrete. Research & Development activities have been taken up all over the world for proving its feasibility, economic viability and cost effectiveness.

The main reasons for increase of volume of demolition concrete / masonry waste are as follows:-

1) Many old buildings, concrete pavements, bridges and other structures have overcome their age and limit of use due to structural deterioration beyond repairs and need to be demolished;
2) The structures, even adequate to use are under demolition because they are not serving the needs in present scenario;
3) New construction for better economic growth;
4) Structures are turned into debris resulting from natural disasters like earthquake, cyclone and floods etc.
5) Creation of building waste resulting from manmade disaster/war

In recycled aggregate concrete bonding between the recycled coarse aggregate and the new motor is low due to the adhered motor around the recycled coarse aggregate. Hence the interfacial transition zone (ITZ) is thicker between RCA and cement paste so the molecular structure of concrete is weak and water absorption is more. The recycled aggregate concrete (RAC) which is composed of many minute pores and cracks, and they critically affect the ultimate strength of the RAC. These pores and cracks also adsorb water, leading to high water content in the new interfacial transition zone (ITZ) of RAC, the pore of the RA, and also tend to accumulate onto the surface of the old concrete. Therefore, the RAC showed a clear reduction of compressive strength and split tensile strength as compared to the NAC. Improving the strength By using a kind of double-mixing method (DM) (or) two-stage mixing approach (TSMA) . The two-stage mixing can help to form a layer of cement slurry on the surface of RCA to fill up the initial damage such as micro-cracks and voids, leading to an improved interfacial zone the premix process can fill up some pores and cracks, resulting in a denser concrete, an improved interfacial zone around RA and thus a equal strength when compared to the normal mixing approach

2. Materials Used

2.1 Cement

Ordinary Portland cement of 53 grade conforming to IS: 12269-1987 was used for this entire study.

Table 1: Tests on Cement

S. No	Properties	Value	Permissible limit as per IS: 12269-1987
1	Specific Gravity	3.13	Varies from 3.1 to 3.15
2	Initial setting time	63min	Should not be less than 30 Min
3	Final setting time	321 min	Should not be more than 600 Min
4	Fineness test	1% retained	<10%

2.2 Fine Aggregate

Locally available river sand passing through IS sieve 4.75mm was used as fine aggregate and the following tests were carried out on a sand as per IS 2386- 1986 (part 3).

Table 2: Tests on Fine Aggregate.

S. No	Particulars of test	Test results
1	Specific gravity	2.61
2	Fineness modulus	2.5
3	Water absorption (%)	1.8
4	Sieve analysis	Zone II

2.3 Coarse Aggregate

For this study, two types of coarse aggregates were used for the preparation of concrete i.e. Natural coarse aggregate (NCA) and Recycled coarse aggregate (RCA). Both NCA and RCA aggregates were screened into two different size fractions (i.e. 70% of 20mm to 16mm sized and 30% of 12mm to 10mm sized) and combined to form NCA & RCA

2.3.1 Natural coarse aggregate

For this study, locally available crushed stone aggregate of size 20mm were used and the following tests were carried out on NCA.

Table 3: Tests on Coarse Aggregate

S. No	Particulars of test	Test results
1	Type	Crushed
2	Specific gravity	2.81
3	Fineness modulus	7.25
4	Water absorption	0.96%

2.3.2 Recycled Aggregate (RCA)

Recycled aggregate were prepared by crushing the M30 grade manufactured cubes. The cubes were cured for 28days and broken into smaller pieces by hammer then sieved to collect maximum size of 20mm and minimum size of 10mm. The following tests were carried out on RCA.

Figure 1: Recycled coarse aggregate

Table 4: Tests on RCA

S. No	Particulars of test	Test results
1	Specific gravity	2.61
2	Fineness modulus	6.87
3	Crushing value (%)	17.23
4	Impact value (%)	20.61

2.4 Water

In this study portable water conforming to IS: 456-2000 was used for casting and curing.

2.5 Fly ash

Fly ash particles are typically spherical ranging in diameter from 1 to 150 microns. The type of dust collection equipment used largely determines the range of particles size in any given fly ash. The fly ash from the boilers where mechanical collectors are used is coarser than fly ash from electrostatic precipitators. Specific gravity of fly ash is 2.13

Figure 2: fly ash

2.6 Glass Fiber

High strength glass made with magnesium alumina silicates. Used where high strength, high stiffness, extreme temperature resistance, and corrosive resistance is needed.

Figure 3: S- Glass Fibers

Table 6: Properties of S-Glass Fibers

Fiber Type	S-Glass fiber
Density (gm/cm3)	2.53
Elastic Modulus (G pa)	89
Tensile Strength (M pa)	4600
Diameter In Microns	10
Length In mm	6
Percent Elongation	5.2

3. Mix design

Concrete mix proportions were designed as per IS 10262:2009 code. A super plasticizer of SP430 was used for high degree of workability. The content of super plasticizer was 0.9% of cement used. The resulting concrete is proportioned for M30 grade as per nominal mix design. The Natural coarse aggregate is replaced by recycled coarse aggregate in percentages i.e., 0%, 25%, 50%, 100% and these

International Journal of Science and Research (IJSR)
ISSN (Online): 2319-7064
Index Copernicus Value (2015): 78.96 | Impact Factor (2015): 6.391

specimens were tested for compression and split tensile strengths. The variations of compressive strength and split tensile strength without RCA and with RCA are discussed in the result section. The table 4.1 show the Concrete mix proportions were designed as per IS: 10262-2009 code for M30.

Table 7: Mix Proportion

Cement (Kg/m^3)	Fine aggregate (Kg/m^3)	Coarse aggregate (Kg/m^3)	Water content (Kg/m^3)
380	674	1204	171

3.1 Mix Proportions

Here three mixes of concrete were prepared i.e., without RCA(Mix 1);with RCA, replacement of fly ash by 10% and 0.015% addition of S-Glass fibers (Mix 2); 20% 0f fly ash and 0.015% (Mix 3). The water-cement ratio is 0.45. To increase the workability of recycled aggregate concrete super plasticizer (SP 430). When super plasticizer (SP430) is used the water-cement ratio is 0.43. The crushed aggregates are used for the replacement of natural aggregates in different proportions such as 0%, 25%, 50%, 75%, and 100%.Tables 8,9 and 10 shows the mix proportions of recycled aggregate concrete with 10% and 20% flyash.

Table 8: Mix Proportion without RCA, different % of fly ash and S-Glass fiber

S. No.	%fly ash (replacement of Cement)	S-glass Fibers	Mix proportions(Kg/m^3)					
			Cement	Fly ash	FA	NCA	S-glass Fibers	Water
1.	0%	0.005%	380	0	674	1204	0.0192	171
		0.015%	380	0	674	1204	0.0577	171
		0.025%	380	0	674	1204	0.0962	171
2.	10%	0.005%	342	38	674	1204	0.0192	171
		0.015%	342	38	674	1204	0.0577	171
		0.025%	342	38	674	1204	0.0962	171
3.	20%	0.005%	304	76	674	1204	0.0192	171
		0.015%	304	76	674	1204	0.0577	171
		0.025%	304	76	674	1204	0.0962	171

Table 9: Mix Proportion with RCA, 10% replacement of fly ash and 0.015% addition of S-Glass fibers

RAC Mix	Source of RCA	% replacement (RCA)	Mix proportions(Kg/m^3)						
			Cement	Fly ash (10%	S-Glass fibers (0.005%)	FA (Sand)	NCA	RCA	Water
M30	M30 (RAC 30)	25	342	38	0.0577	674	903	301	168
		50	342	38	0.0577	674	602	602	168
		75	342	38	0.0577	674	301	903	168
		100	342	38	0.0577	674	0	1204	168

Table 10: Mix Proportion with RCA, 20% replacement of fly ash and 0.015% addition of S-Glass fiber

RAC Mix	Source of RCA	% replacement (RCA)	Mix proportions(Kg/m^3)						
			Cement	Fly ash (20%)	S-Glass fibers (0.015%)	FA (Sand)	NCA	RCA	Water
M30	M30 (RAC 30)	25	304	76	0.0577	674	903	301	168
		50	304	76	0.0577	674	602	602	168
		75	304	76	0.0577	674	301	903	168
		100	304	76	0.0577	674	0	1204	168

3.2 Mixing Procedure

Mixing of ingredients is done in pan mixer of capacity 50 liters. The cementations materials are thoroughly blended and then the aggregate is added and mixed followed by gradual addition of water and mixing. Wet mixing is done until a mixture of uniform colour and consistency are achieved which is then ready for casting. Before casting the specimens, workability of the mixes was found by slump cone test.

There are 3 types of mixing methods
a) Normal mixing method
b) Double mixing method

c) Triple mixing method

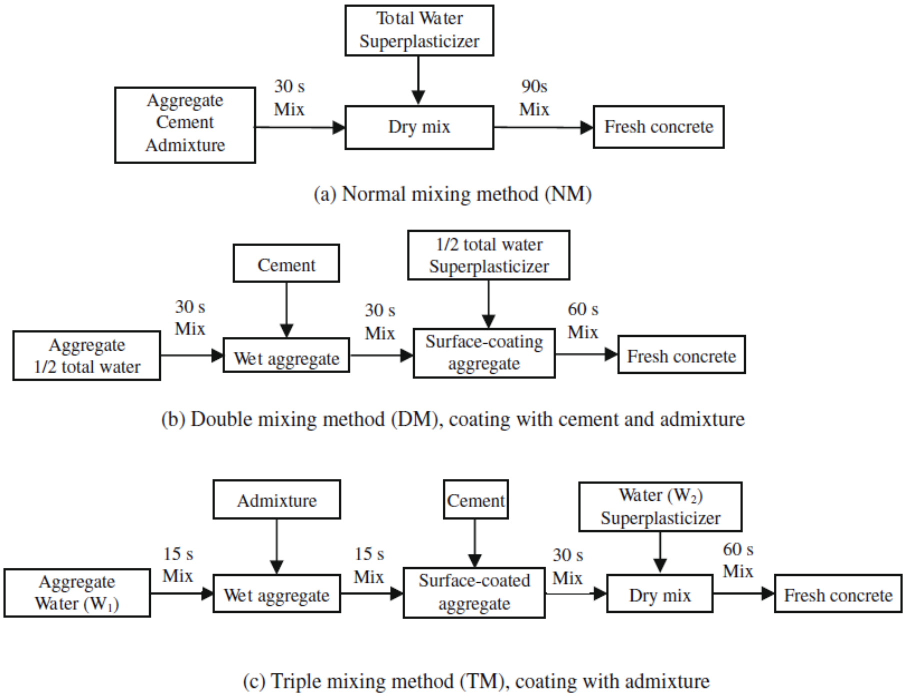

Figure 4: Mixing Methods

3.2.1 Double Mixing Method (DM)

Here in this project Double mixing method is adopted. In double mixing method, the coarse aggregates and fine aggregates are mixed first. To that aggregates half of the total quantity of water is added and mixed thoroughly about 30 seconds in the pan mixer, so that the surface of the aggregates becomes wet. To the wet aggregates, cement and the proportioned admixture is added and mixed thoroughly for 30 seconds so that the surface of the coarse aggregates is get coated with cement. Now the remaining half of the quantity of the water in addition to the super plasticizer is added and mixed completely about 60 seconds in the pan mixer to become fresh concrete. By doing this the physical surface of the recycled aggregates are getting enhanced by filling the cracks and pores which are present on the recycled aggregates surface. This type of mixing increases the bond strength between the recycled coarse aggregates and newly formed cement paste

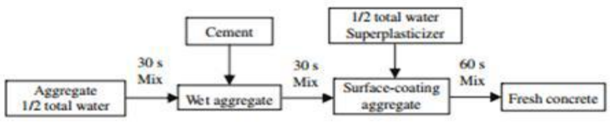

Figure 5: Double Mixing Method (DM)

4. Results and Discussions

4.1 Compressive Strength

The experimental results obtained after the curing of 7 days and 28 days are shown in the table 11 & 12. Figures 5, 6, 7 & 8 represent the compressive strength for 7 days &28 days without RCA and Figure 9 represent the compressive strength for 7 days &28 days Replacement of RCA (0% to 100%) with 20% fly ash and 0.015% S-Glass fibers. The compressive strength is decreased with the increase in percentage of recycled aggregates. At 28 days 100% replacement of RCA with addition of fly ash achieves strength of 32mpa where as target mean strength of M30is 38.9mpa. In short period of time this strength can exceed to the strength of natural aggregate concrete.

Table 11: Compressive strength for 7 and 28 days without RCA

S. No	% fly ash (replacement of Cement)	S-glass Fibers	Compressive Strength (M pa)	
			7 days	28 days
1.	Normal mix		25.7	42.22
2.	0%	0.005%	26.48	40.42
		0.015%	27.54	41.54
		0.025%	27.22	41.06
3.	10%	0.005%	27.63	41.84
		0.015%	28.76	42.35
		0.025%	27.87	41.90
4.	20%	0.005%	28.44	42.83
		0.015%	29.69	43.26
		0.025%	28.37	42.93
5.	25%	0.005%	25.93	38.45
		0.015%	26.57	39.67
		0.025%	24.88	37.58

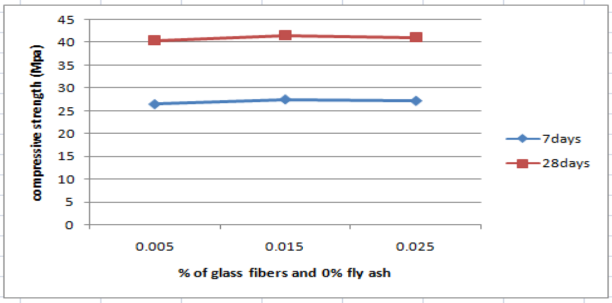

Figure 5: Compressive strength for 7 and 28 days 0% fly ash without RCA

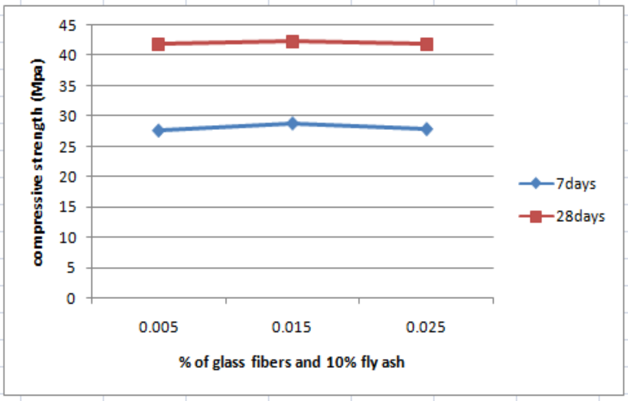

Figure 6: Compressive strength for 7 and 28 days 10% fly ash without RCA

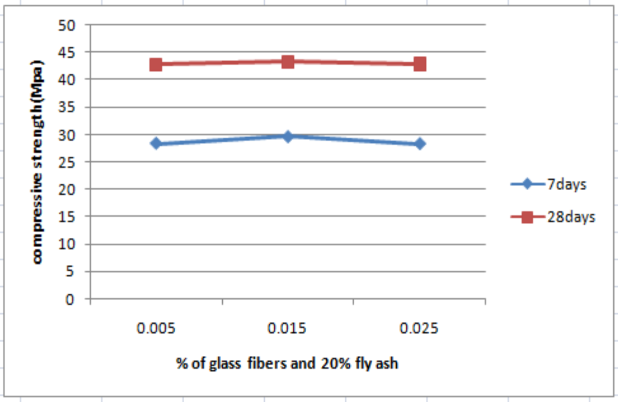

Figure 7: Compressive strength for 7 and 28 days 20%fly ash without RCA

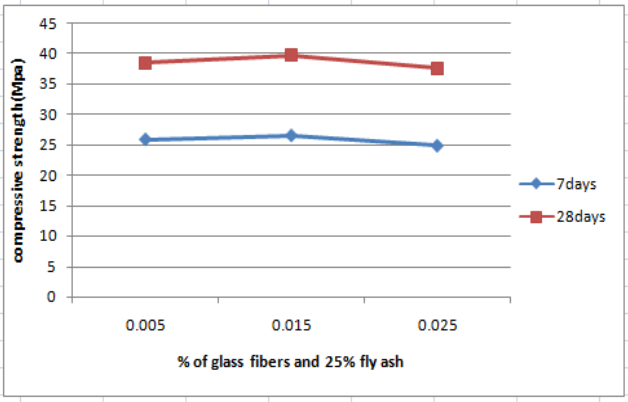

Figure 8: Compressive strength for 7 and 28 days 25fly ash without RCA

Table 12: Compressive strength for 7 and 28 days with RCA

Optimum		*% of*	*Compressive Strength (M pa)*	
Fly ash	*S-Glass fibers*	*RCA*	*7 days*	*28 days*
20%	0.015%	0	29.69	43.26
		25	27.09	41.46
		50	24.49	38.66
		75	21.89	35.86
		100	19.29	32.66

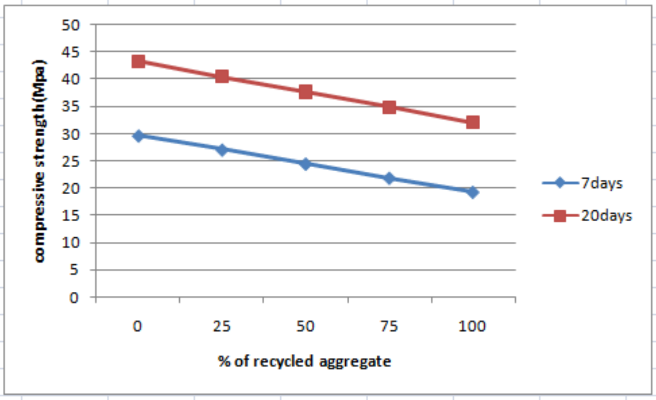

Figure 9: Compressive strength for7 days and 28 days with 0% to 100%RCA, 20%fly ash and 0.015% GF

4.2 Split Tensile Strength

The split tensile strength results obtained after the curing of 7 days and 28 days are shown in the table 13 & 14. Figures 10, 11, 12, 13 represent the split tensile strength for 7 days &28 days without RCA and Figure 14 represent the split tensile strength for 7 days &28 days Replacement of RCA (0% to 100%) with 10% fly ash and 0.015% S-Glass fibers.

The split tensile strength of the three sets is also decreased with the increase in percentage of recycled aggregates. The split tensile strength also shows the similar pattern of results as the compressive strength results.

Table 13: Split Tensile strength for 7 and 28 days without RCA

s. no	*% fly ash(replacement Of Cement)*	*S-glass Fibers*	*split tensile strength (M pa)*	
			7days	*28days*
1	*Normal mix*		2.79	4.15
2	0%	0.005%	2.97	3.96
		0.015%	3.08	4.12
		0.025%	3.03	4.05
3	10%	0.005%	3.2	4.27
		0.015%	3.27	4.36
		0.025%	3.21	4.29
4	20%	0.005%	3.16	4.22
		0.015%	3.19	4.26
		0.025%	3.12	4.17
5	25%	0.005%	2.9	3.87
		0.015%	2.94	3.93
		0.025%	2.97	3.96

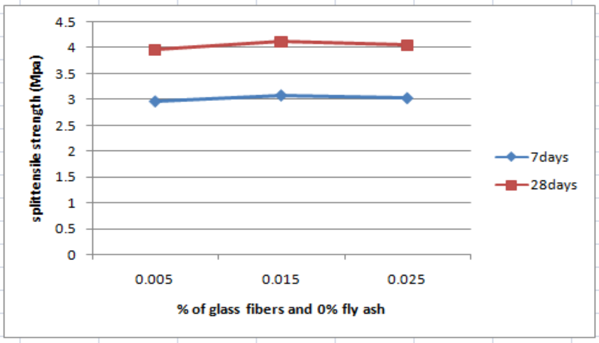

Figure 10: Split Tensile strength for 7 and 28 days 0% fly ash without RCA

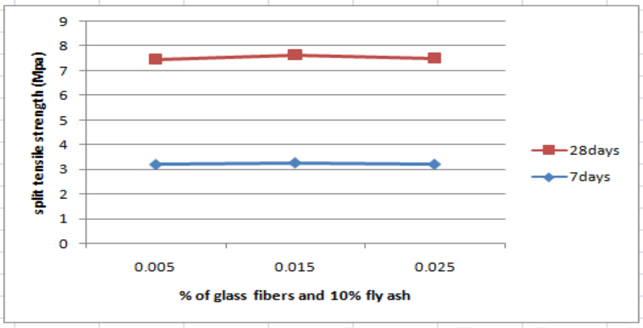

Figure 11: Split Tensile strength for 7 and 28 days 10% fly ash without RCA

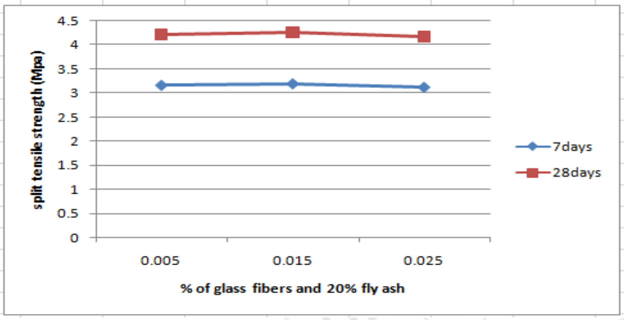

Figure 12: Split Tensile strength for 7 and 28 days 20% fly ash without RCA

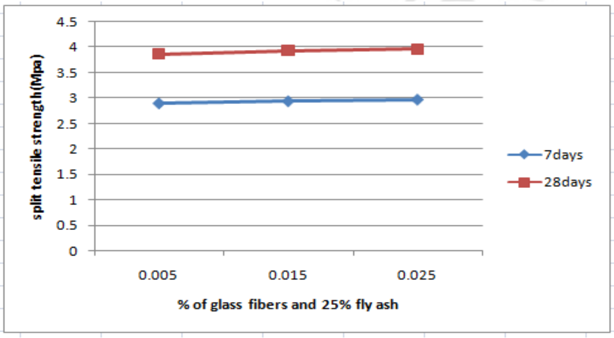

Figure 13: Split Tensile strength for 7 and 28 days 25% fly ash without RCA

Table 14: Split Tensile strength for 7 and 28 days with RCA

Optimum		*% of RCA*	*split tensile strength (M pa)*	
Fly ash	*S-Glass fibers*		*7 days*	*28 days*
10%	0.015%	0	3.27	4.36
		25	3.02	4.01
		50	2.77	3.85
		75	2.52	3.58
		100	2.27	3.29

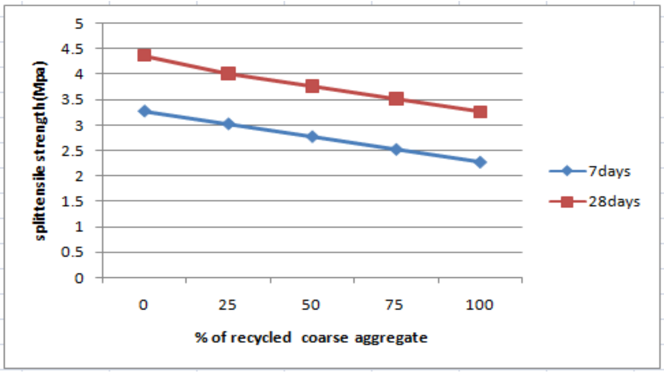

Figure 14: Split Tensile strength for7 days and 28 days with 0% to 100%RCA, 10% fly ash and 0.015% GF

5. Conclusions

The following conclusions are made from the study:

1) The strength of concrete decrease with increase in the percentage of recycle aggregate, this may be because of the loose mortar around the recycle aggregate which do not allow the proper bonding between the cement paste and aggregate.
2) The strength (30 MPa) is generally used for a wide range of structural uses. At 28 days 100% replacement of RCA with addition of fly ash achieved strength of 32 MPa.
3) The split tensile strength value is maximum with the addition of S-Glass Fibers at 0.015%.
4) When the Natural Aggregate is replaced with 50% RCA, 20% fly ash and 0.015% S-Glass fibers achieved the target mean strength for M30 grade of concrete.
5) At 20% fly ash, 0.015% S-Glass fibers and 50% RCA replacement to NCA increases compressive strength
6) At 10% fly ash, 0.015% S-Glass fibers and 50% RCA replacement to NCA increases split tensile strength.
7) It is concluded that without decreasing the water-cement ratio, the target mean strength of M25 grade of concrete can be achieved through recycled aggregates and fly ash.

References

[1] Dabhade A.N., Choudhari S.R., Gajbhiye A.R., "Experimental study of effects of fly-ash on recycled concrete", International journal of applied engineering and technology ISSN: 2277-212X (online).

[2] My le Nguyen James, Wonchang Choi and Taher Abu-Lebdeh, "Use of Recycled Aggregate and Fly Ash in Concrete Pavement", American J. of Engineering and Applied Sciences 4 (2): 201-208, 2011.

[3] Shi-Cong Kou,Chi-Sun Poon, "Long-term mechanical and durability properties of recycled aggregate concrete prepared with the incorporation of fly ash", Cement & Concrete Composites 37 (2013) 12–19.

[4] Mukesh Limbachiya, Mohammed Seddik Meddah, Youssef Ouchagour, "Use of recycled concrete aggregate in fly-ash concrete", Construction and Building Materials 27 (2012) 439–449.

[5] M.L. Berndt, "Properties of sustainable concrete containing fly ash, slag and recycled concrete aggregate",

Construction and Building Materials 23 (2009) 2606–2613.

[6] Weerachart Tangchirapat, Chaiyanunt Rattanashotinunt, Rak Buranasing, Chai Jaturapitakkul, "Influence of fly ash on slump loss and strength of concrete fully incorporating recycled concrete aggregates", J. Mater. Civ. Eng. 2013.25:243-251.

[7] Pierre Matar, Rouba El Dalati, "Strength of masonry blocks made with recycled concrete aggregates", Physics Procedia 21 (2011) 180 – 186.

[8] Y. V. Akbari, N. K. Arora, M. D. Vakil, "Effect on recycled aggregate on concrete properties", International Journal of Earth Sciences and Engineering ISSN 0974-5904, Volume 04, No 06 SPL, October 2011, pp. 924-928.

[9] A.K. Padmini, K. Ramamurthy , M.S. Mathews, "Influence of parent concrete on the properties of recycled aggregate concrete", Construction and Building Materials 23 (2009) 829–836.

[10] C.S. Poon, Z.H. Shui, L. Lam, H. Fok, S.C. Kou, "Influence of moisture states of natural and recycled aggregates on the slump and compressive strength of concrete", Cement and Concrete Research 34 (2004) 31–36.

[11] S.W. Forster, "Recycled concrete as coarse aggregate in concrete".

[12] WANG Zhenshuang,WANG Lijiu,CUI Zhenglong,ZHOU Mei, "Effect of Recycled Coarse Aggregate on Concrete Compressive Strength", Trans. Tianjin Univ. 2011, 17: 229-234.

[13] ZHANG Xue-bing, DENG Shou-chang, QIN Yin-hui, J. Cent, "Additional adsorbed water in recycled concrete". South Univ. Technol. 2007, 14(s1).

[14] Sudhir p.patil, ganesh s.ingle, prashant d.sathe, "Recycled coarse aggregates", International Journal of Advanced Technology in Civil Engineering, ISSN: 2231 –5721, Volume-2, Issue-1, 2013.

[15] S. R. Rabadiya S. R. Vaniya "Effect of Recycled Aggregate with Glass Fiber on Concrete Properties" IJIRST –International Journal for Innovative Research in Science & Technology| Volume 2 | Issue 01 | June 2015 ISSN (online): 2349-6010

[16] P.R. Srinivasa et al., "Strength Properties Of Glass Fibre Concrete", APRN journal, vol 5,no 4, april 2010