Effect of Recycled Aggregate with Glass Fiber on Concrete Properties

S. R. Rabadiya
D.I.E.T. – Rajkot

S. R. Vaniya
D.I.E.T. – Rajkot

Abstract

Concrete made from glass fiber and recycled coarse aggregate as partial replacement of coarse aggregate will be studied for workability, compressive strength, tensile strength, and modulus of elasticity. I will use recycled coarse aggregate as partial replacement of coarse aggregate by different percentage for making concrete of different grade from lower to higher like M-20. The percentage replacement will be 0%, 10%, 20%, 30%, 40%, 50% and 60% with natural coarse aggregate. I will prepare cubes, cylinders, beams and finally slump test, compressive strength test, splitting tensile strength test and flexural strength test will be conducted to obtain the necessary results. A large no. of trial mixes are required to select the desired optimum replacement of coarse aggregate by recycled coarse aggregate.

Keywords: Recycled Aggregate, Glass Fiber

I. INTRODUCTION

A. General

It is defined a strong plastic, textile, or other material containing embedded glass filaments for reinforcement. It is chemical inorganic fiber, obtained from molten glass of a specific composition. This glass is compound of sand, limestone, alcium fluoride, boric acid and clay. It is made of natural materials, so that its products are ecologically pure and not harmful to human health.

B. Historical development

The original patent of fiber glass was approved in 1946, the many uses of this material have increased substantially attesting to its versatility under exteme environment condition. Underground chemical storage tanks made of fiber glass must last over 50 years. Since 1959, Accurate Dorwin Co. a leader in the fenestration industry has been in the business making the quality and highest energy rated windows and door since 1952 from Canada. Since 1983

C. Objectives and Scope of the study

The main objectives of the study is to investigate the performance of woven rowing glass fibers based concrete with a difference percentages proportion of recycled coarse aggregate. To investigate the hardened concrete made with partial replacement coarse aggregate with recycled coarse aggregate and glass fiber. To investigate the hardened properties (compressive strength, flexural strength and tensile strength) of concrete for M20 grade of concrete mix. Scope of the study is limited to M20 grade of concrete only. At the same time the it should be noted that only woven type glass fibers have been selected for study.

D. Types of Fiber

- E glass (Polyethylene glass fiber)
- P glass (Polypropylene glass fiber)
- O glass (Woven roving glass fiber)
- AR glass (Alkali Resistance glass fiber)

Fig. 1.1: Type of glass fiber

Fig. 2: Fiber

II. LITERATURE REVIEW

A. Research Papers

1) Yogesh Iyer Murthy and el (2012)

carried out study on the compressive strength, flexural strength and workability of concrete containing varying proportions of glass fiber as replacement of fine aggregate. 25 micrometer in diameter and 5cm long are used for the preparation of standard M30 grade concrete by replacing fine aggregate by fiber up to 1.5%. The increase in compressive strength is nominal while the flexural strength increased significantly as expected with the increase in percentage of glass fiber. The reduction in slump with the increase in glass fiber content. The flexural strength of beam with 1.5% glass fiber shows almost 30% increase in the strength compared to the beam with 0% glass fiber. In this research concrete with glass fiber is made cost effective and solve the problem of disposal, to make environment greener.

2) P.R. Srinivasa and el (2010)

Carried out study on strength properties of glass fiber concrete. In this paper experimental investigation the alkali resistance glass fibers used are of cem FIL anti crack HD with modulus of elasticity 72 Gpa, filament diameter 14 microns, specific gravity 2.68,length 12 mm and having the aspect ratio of 857.1 to study the effect on compressive, split tensile and flexural strength on M20, M30, M40 and M50 grades of concrete. The addition of glass fibers 0.03% by concrete volume. Compressive strength is increased by 20 to 25% of all above mentioned grade. the percentage increased of flexural and split tensile strength of various grades of glass fiber concrete mixes compared with 28 days is observed from 15 to 20%.

3) Rama Mohan Rao and el (2010)

In the experimental glass fibers in different volume fraction with 25% and 40% replacement of cement by fly ash has been used to study the effect on compressive, split and flexural strength of concrete. in this research fly ash was used to replace OPC at various levels of 0%,25% and 40% by mass of binding. the E glass fibers of 0.1%,0.2% and 0.3% by volume of concrete were used.the addition of glass fibres in to the fly ash concrete improves the compressive strength.the flexural strength of 25% FA replace with addition of glass fibre shows comparable with plain concrete.the volume fraction of glass fibre 0.3% gives better strength values on control mix.

4) Suresh Babu.R and el (2013)

The present study concentrates the behavior of fiber reinforced concrete with two different concrete strength(M25 & M50) and different percentage of fiber additions(0.5, 1, 1.5%). Concrete is rigid material with high compressive strength and weak in tensile strength.

Table - 1
Concrete

Grade of concrete	*Permeability index value*	*Glass fiber*
M25	*6.4%*	*0.5%*
	12.6%	*1.0%*
	26.3%	*1.5%*
M50	*8.7%*	*0.5%*
	15%	*1.0%*
	30.1%	*1.5%*

Compressive strength increase by,

Table – 2
Compressive strength increase

Grade of concrete	*% of increase value comp. strength*	*Glass fiber*
M25	*16.4%*	*0.5%*
	24.7%	*1.0%*
	47.3%	*1.5%*

M50	*14.3%*	*0.5%*
	22.3%	*1.0%*
	43.5%	*1.5%*

5) Khaldoum Rahal and el (2005)

The experimental study on some of the mechanical properties of recycled aggregate concrete (RAC) as compared to those of the conventional normal aggregate concrete (NAC). Studies waste concrete was obtained from two building under demolition. Most old construction in that howally area took place 20-40 place. The concrete with cylinder compressive strengths between 25 and 50 Mpa, the modulus of elasticity of RAC was only 3% lower than that of NAC. The coefficient of variation ranged from 2.16% to 3.27% with an average of 2.73% for RAC and between 1.87% and 4.18% with an average of 2.60 for NAC. The 28 days compressive strength for all five mixes were achieved except for the 40 and 50Mpa RAC where the observed strength was slightly lower than the target strength.

6) Andrzej M. Brandt and el(2008)

In this paper the main fields of application of FRC composites are examined and future perspectives discussed. Used self-compacting concrete (SCC), silica fume(SF), carbon fiber reinforced mortar(CFRM), slurry infiltratedfiber concrete(SIFCON). Because fibers are an important part of the cost, the fiber volume in ordinary applications is usually limited to 0.5% or even lower. The application of FRC in building and civil engineering structures are used in steel fibers and natural vegetal fibers.

7) Nikhil gupta and el (2001)

Effect of specimen aspect ratio on the compressive strength values is also studied by testing specimens of three different aspect ratios. The fibers having diameter of about 10 microns were cut into 2.54 cm size. Density of glass fiber is 2.54 g/cc. To study the effect of specimen aspect ratio of the compressive strength values, three different heights 15 mm, 20 mm and 25 mm were taken aspect ratio of 1.5,2.0 and 2.5 respectively. The high compressive strength are fiber volume fraction is 4.2, specimen ratio is 2.5 then strength is 105.26 Mpa and flyash filler type, filler volume fraction 5.1, fiber volume 3.98 and specimen ration 2.0 then strength is 76.77 Mpa. Impact strength high of flyash filler type, filler volume fraction is 5.1, fiber volume fraction is then strength is $17.6 * 10^{-3}$.

III. PILOT TEST

A. Preliminary Mixture Proportion

Table – 3
Mix pro. of used glass fiber concrete for pilot study (w/c ratio 0.5)

CONSTITUENTS	*UNIT*	*MIXTURE*
Used of Glass Fiber	*Kg/m^3*	*0.005% ,0.015% and 0.025%*
Fine Aggregate	*Kg/m^3*	*583*
Coarse Aggregate (20 mm)	*Kg/m^3*	*1282*
Cement	*Kg/m^3*	*383*
Water	*Kg/m^3*	*191.6*

Table – 4
Mix pro. of used glass fiber concrete for pilot study (w/c ratio 0.4)

CONSTITUENTS	*UNIT*	*MIXTURE*
Used of Glass Fiber	*Kg/m^3*	*0.005% ,0.015% and 0.025%*
Fine Aggregate	*Kg/m^3*	*1224*
Coarse Aggregate (20 mm)	*Kg/m^3*	*556*
Cement	*Kg/m^3*	*479*
Water	*Kg/m^3*	*191.6*

B. Trial Mix

Table – 5
Trial Mix

Trial Mix No.	*W/C ratio*	*Glass Fiber(vol. of conc.)*	*Cement (kg/m^3)*	*Fine aggregate (kg/m^3)*	*Coarse aggregate (kg/m^3)*	*Recycled Coarse agg. (kg/m^3)*	*Water (kg/m^3)*
1.	*0.5*	*0.00%*	*383*	*583*	*1282*	*0.00(0%)*	*191.6*
2.	*0.5*	*0.005%*	*383*	*583*	*1282*	*0.00(0%)*	*191.6*
3.	*0.5*	*0.005%*	*383*	*583*	*641*	*641(50%)*	*191.6*
4.	*0.5*	*0.015%*	*383*	*583*	*1282*	*0.00(0%)*	*191.6*
5.	*0.5*	*0.015%*	*383*	*583*	*641*	*641(50%)*	*191.6*
6.	*0.5*	*0.025%*	*383*	*583*	*1282*	*0.00(0%)*	*191.6*
7.	*0.5*	*0.025%*	*383*	*583*	*641*	*641(50%)*	*191.6*
8.	*0.4*	*0.00%*	*479*	*556*	*1224*	*0.00(0%)*	*191.6*
9.	*0.4*	*0.005%*	*479*	*556*	*1224*	*0.00(0%)*	*191.6*
10	*0.4*	*0.005%*	*479*	*556*	*612*	*612(50%)*	*191.6*

11	*0.4*	*0.015%*	*479*	*556*	*1224*	*0.00(0%)*	*191.6*
12	*0.4*	*0.015%*	*479*	*556*	*612*	*612(50%)*	*191.6*
13	*0.4*	*0.025%*	*479*	*556*	*1224*	*0.00(0%)*	*191.6*
14	*0.4*	*0.025%*	*479*	*556*	*612*	*612(50%)*	*191.6*

C. Results of Compressive strength (pilot test)

Table – 6
Results of Compressive strength (Pilot test results)

Trial Mix No.	*Glass Fiber (vol. of concrete)*	*7 day (N/mm^2)*	*14day (N/mm^2)*	*28day(N/mm^2)*
1.	*0.00%*	*14.38*	*18.00*	*26.62*
2.	*0.005%*	*15.10*	*20.00*	*21.55*
3.	*0.005%*	*12.00*	*13.71*	*15.11*
4.	*0.015%*	*17.62*	*19.54*	*22.98*
5.	*0.015%*	*14.58*	*15.47*	*18.31*
6.	*0.025%*	*23.61*	*24.80*	*26.00*
7.	*0.025%*	*16.81*	*17.07*	*20.77*
8.	*0.00%*	*16.87*	*19.82*	*28.64*
9.	*0.005%*	*16.52*	*20.98*	*23.56*
10.	*0.005%*	*13.62*	*14.51*	*17.00*
11.	*0.015%*	*18.23*	*20.35*	*24.01*
12.	*0.015%*	*14.99*	*16.05*	*19.68*
13.	*0.025%*	*24.08*	*25.71*	*27.68*
14.	*0.025%*	*17.85*	*19.02*	*22.89*

1) Compressive strength result after 7 days curing with two different water cement ratio (recycled coarse aggregate 0% replaced on natural coarse aggregate)

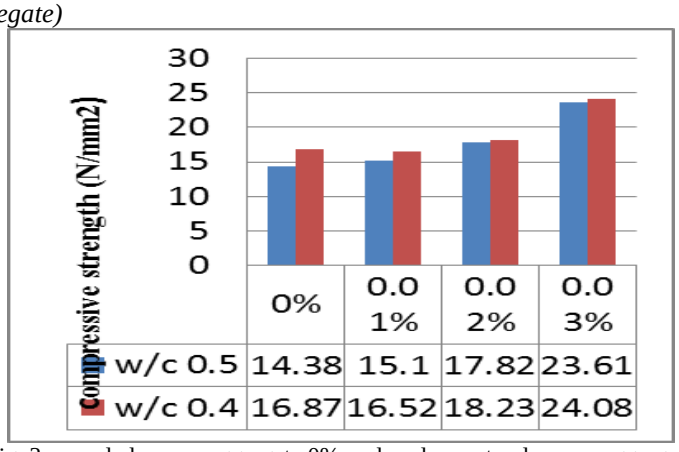


Fig. 3: recycled coarse aggregate 0% replaced on natural coarse aggregate

2) Compressive strength results after 28 days curing with two different water cement ratio (recycled coarse aggregate 0% replaced on coarse aggregate)

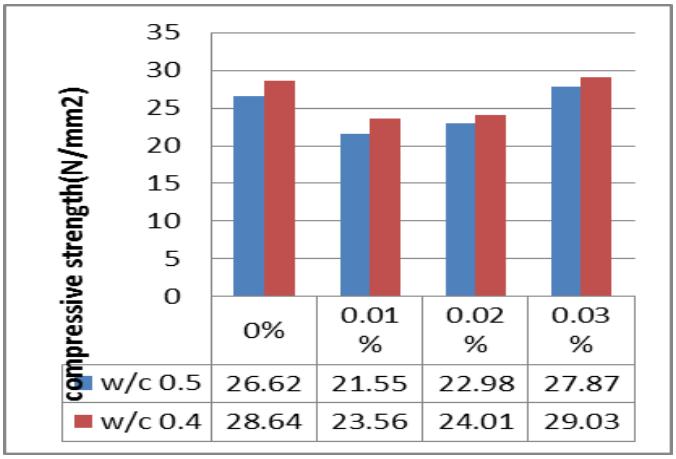


Fig. 4: recycled coarse aggregate 0% replaced on coarse aggregate

3) Compressive strength results after 7 days curing with two different water cement ratio (recycled coarse aggregate 50 % replaced on coarse aggregate)

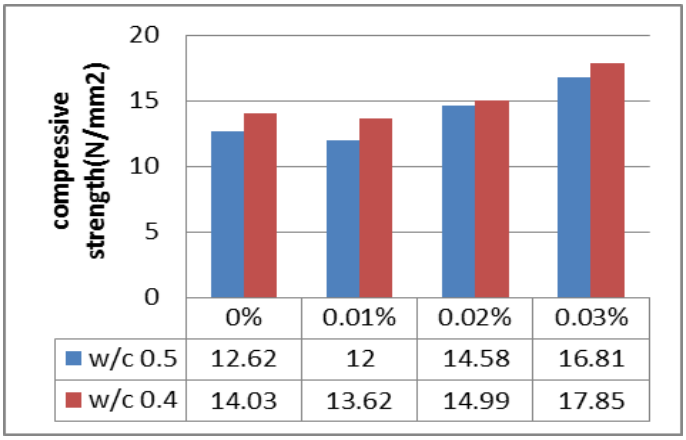


Fig. 5: Compressive strength results

4) Compressive strength results after 28 days curing with two different water cement ratio (recycled coarse aggregate 50 % replaced on coarse aggregate)

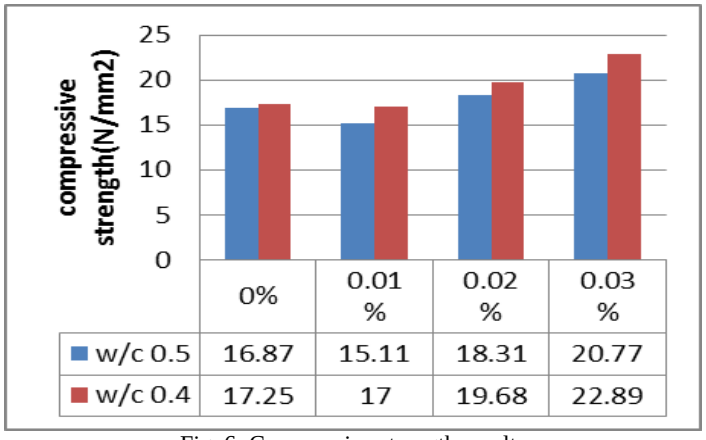


Fig. 6: Compressive strength results

IV. EXPERIMENTAL INVESTIGATION

A. Slump Test results

1) Graphical Results of Slump Test (w/c ratio 0.5)

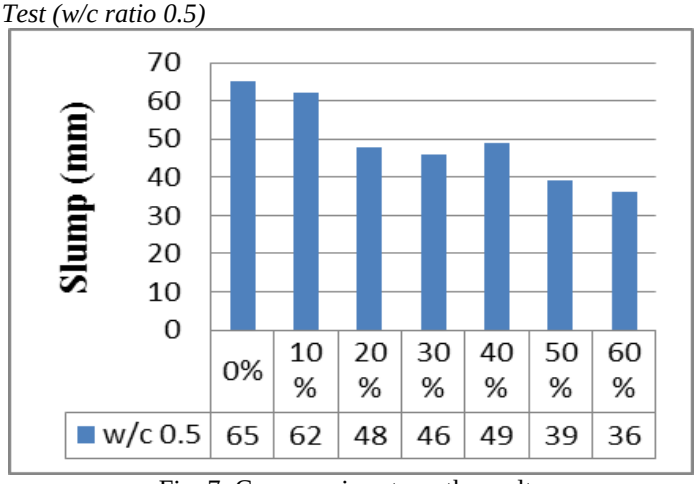


Fig. 7: Compressive strength results

2) Graphical Results of Slump Test (w/c ratio 0.4)

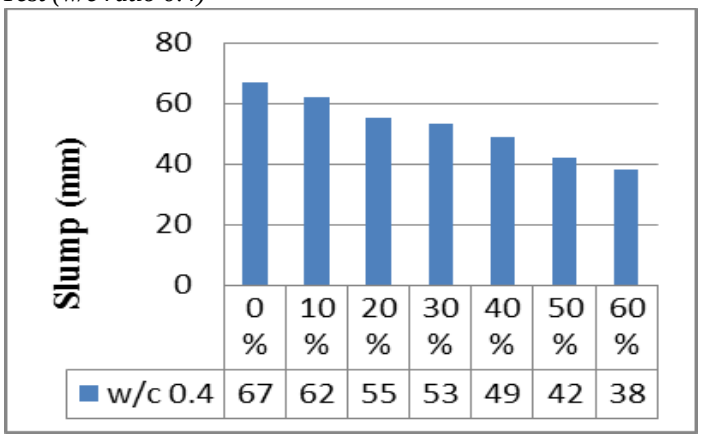


Fig. 8: Graphical Results of Slump Test (w/c ratio 0.4)

B. Result and Discussion of Compressive Strength

By replacement of used recycled coarse aggregate in concrete, the compressive strength was increases up to 40% and then after starts decreasing. The percentages of replacement of recycled coarse aggregate and glass fiber 0.025%(volume of concrete) was increases from 0% to 40%, compressive strength which maximum increase was observed at 30% as compare to normal concrete test result for both water cement ratio.

Table – 7
Result and Discussion of Compressive Strength

Trial Mix No.	*w/c Ratio*	*7 day (N/mm^2)*	*14 day (N/mm^2)*	*28 day (N/mm^2)*
1.	*0.5*	*16.74*	*19.87*	*26.09*
2.	*0.5*	*22.76*	*24.90*	*27.22*
3.	*0.5*	*21.63*	*23.52*	*25.61*
4.	*0.5*	*20.91*	*22.30*	*24.91*
5.	*0.5*	*20.50*	*20.61*	*22.95*
6.	*0.5*	*17.91*	*19.12*	*21.08*
7.	*0.5*	*16.07*	*17.65*	*18.96*
8.	*0.4*	*19.37*	*21.46*	*29.37*
9.	*0.4*	*25.03*	*26.31*	*31.48*
10.	*0.4*	*24.07*	*24.87*	*29.65*
11.	*0.4*	*22.70*	*23.49*	*27.37*
12.	*0.4*	*21.60*	*21.97*	*23.11*
13.	*0.4*	*19.34*	*20.16*	*21.52*
14.	*0.4*	*17.90*	*19.02*	*19.66*

1) Graphical Results of Compressive Strength (w/c ratio 0.5)

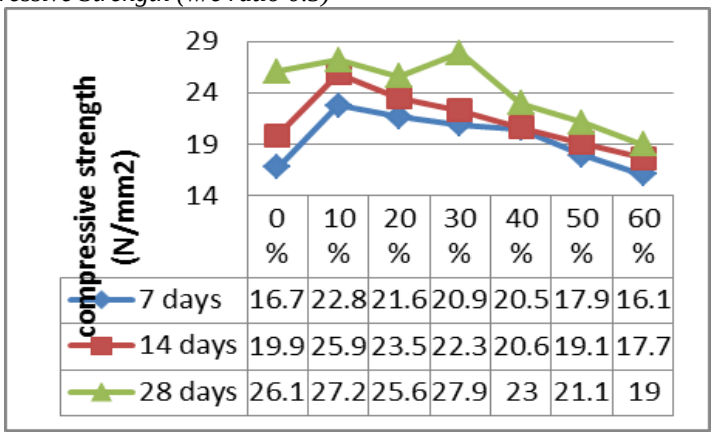


Fig. 9: Graphical Results of Compressive Strength (w/c ratio 0.5)

2) Graphical Results of Compressive Strength (w/c ratio 0.4)

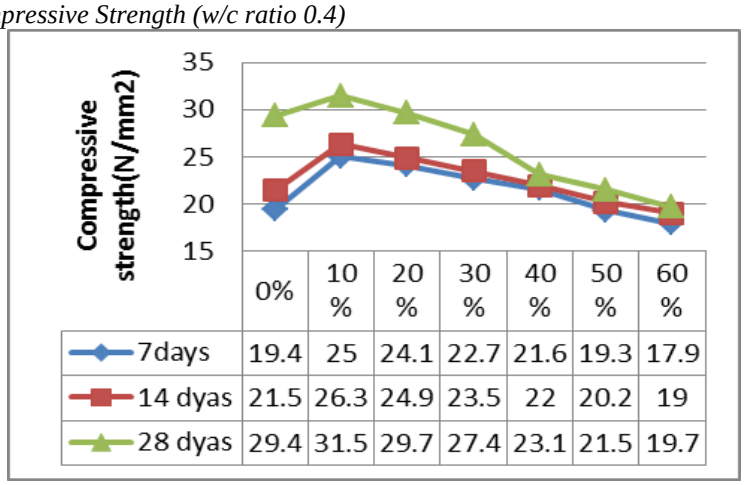


Fig. 10: Graphical Results of Compressive Strength (w/c ratio 0.4)

C. Result and Discussion of Flexural Strength

By replacement of recycled coarse aggregate in concrete, the flexural tensile strength was increases up to 50% and then after starts decreasing. The percentages of replacement of used recycled coarse aggregate and glass fiber 0.025%(volume of concrete) was increases from 0% to 65%, flexural tensile strength which maximum increase was observed at 40% as compare to normal concrete test result for both water cement ratio.

Table – 8
Result and Discussion of Flexural Strength

Trial Mix No.	*7 day (N/mm^2)*	*14 day (N/mm^2)*	*28 day (N/mm^2)*
1.	*3.60*	*4.11*	*4.53*
2.	*4.19*	*4.79*	*5.63*
3.	*3.81*	*4.56*	*5.13*
4.	*3.47*	*4.33*	*4.81*
5.	*3.16*	*3.84*	*4.18*
6.	*3.04*	*3.48*	*3.85*
7.	*2.89*	*3.09*	*3.41*
8.	*3.80*	*4.60*	*4.63*
9.	*4.43*	*4.91*	*5.66*
10.	*3.97*	*4.71*	*5.31*
11.	*3.75*	*4.53*	*4.86*
12.	*3.36*	*4.03*	*4.30*
13.	*3.20*	*3.65*	*3.97*
14.	*2.96*	*3.30*	*3.59*

1) Graphical Results of Flexural Strength (w/c ratio 0.5)

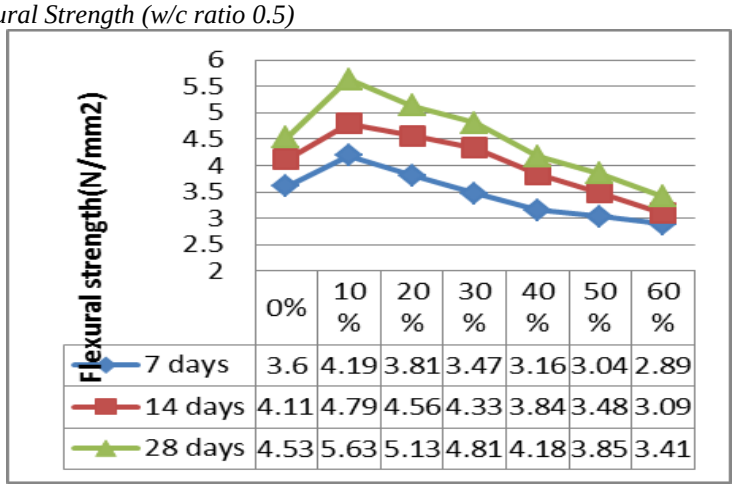


Fig. 11: Graphical Results of Flexural Strength (w/c ratio 0.5)

2) Graphical Results of Flexural Strength (w/c ratio 0.4)

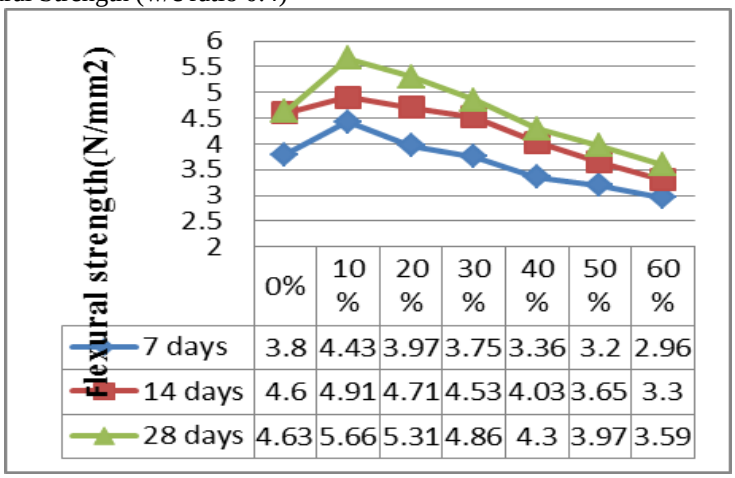


Fig. 12: Graphical Results of Flexural Strength (w/c ratio 0.4)

D. Result and Discussion of Split Tensile Strength

By replacement of used recycled coarse aggregate in concrete, the split tensile strength was increases up to 50% and then after starts decreasing. The percentages of replacement of used recycled coarse aggregate and glass fiber 0.025%(volume of concrete)was increases from 0% to 50%, split tensile strength which maximum increase was observed at 30% as compare to normal concrete test result for both water cement ratio.

Table – 9
Result and Discussion of Split Tensile Strength

Trial Mix No.	*w/c Ratio*	*7 day (N/mm^2)*	*14 day (N/mm^2)*	*28 day (N/mm^2)*
1.	*0.5*	*2.56*	*3.56*	*4.01*
2.	*0.5*	*3.80*	*4.32*	*4.80*
3.	*0.5*	*3.56*	*4.09*	*4.27*
4.	*0.5*	*3.21*	*3.81*	*3.94*
5.	*0.5*	*3.00*	*3.33*	*3.61*
6.	*0.5*	*2.76*	*3.05*	*3.25*
7.	*0.5*	*2.51*	*2.72*	*2.79*
8.	*0.4*	*2.91*	*3.82*	*4.38*
9.	*0.4*	*4.00*	*4.46*	*4.94*
10.	*0.4*	*3.81*	*4.25*	*4.59*
11.	*0.4*	*3.60*	*4.05*	*4.20*
12.	*0.4*	*3.33*	*3.61*	*3.84*
13.	*0.4*	*2.97*	*3.59*	*3.61*
14.	*0.4*	*2.71*	*2.97*	*3.16*

3) Graphical Results of Split Tensile Strength (w/c ratio 0.5)

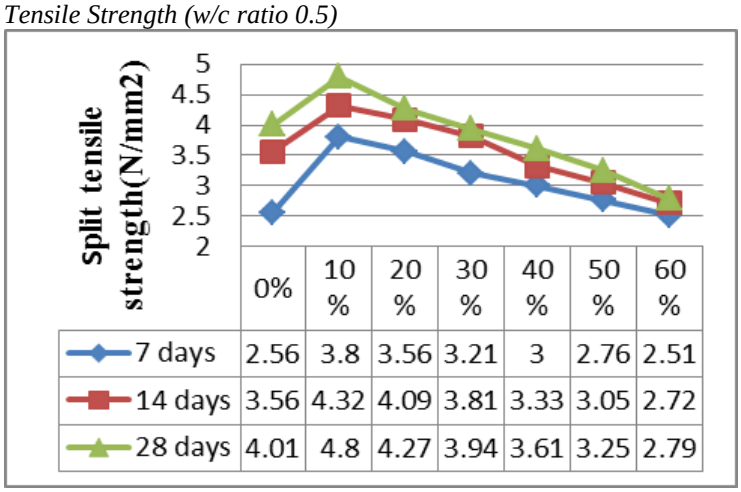
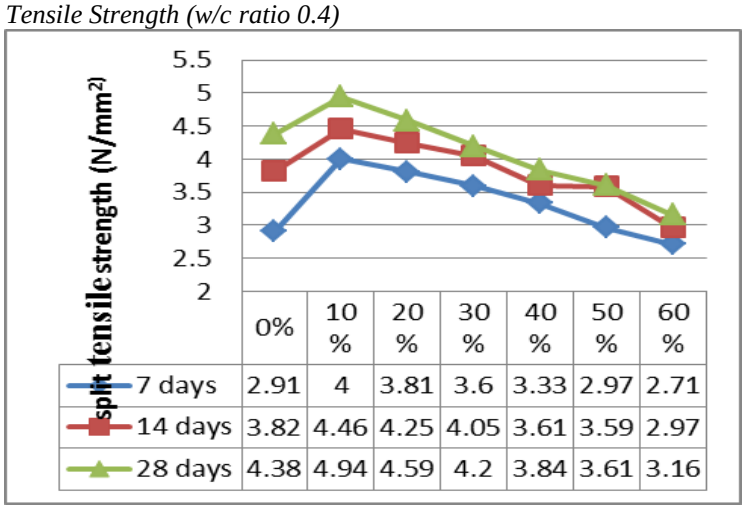


Fig. 13: Graphical Results of Split Tensile Strength (w/c ratio 0.5)

4) Graphical Results of Split Tensile Strength (w/c ratio 0.4)



	0%	10 %	20 %	30 %	40 %	50 %	60 %
7 days	2.91	4	3.81	3.6	3.33	2.97	2.71
14 days	3.82	4.46	4.25	4.05	3.61	3.59	2.97
28 days	4.38	4.94	4.59	4.2	3.84	3.61	3.16

Fig. 14: Graphical Results of Split Tensile Strength (w/c ratio 0.4)

V. CONCLUSION AND FUTURE SCOPE

A. Conclusion

Experiments were performed to predict the behaviour of recycled coarse aggregate Based glass fiber reinforced M20 grade of concrete. Following conclusions were drawn based on the results.

1) Addition of glass fiber decreases the workability of concrete.
2) The recycled coarse aggregate based Woven rowing Glass fiber reinforced concrete gives higher flexural and split tensile than conventional concrete.
3) All recycled coarse aggregate based Glass fiber reinforced concrete specimen have low micro pore and low capillary porn which indicated the low permeability when water absorption test was performed.
4) After performing 14 cycles of wetting drying test on all the mixes, a common trend of increased flexural and split tensile is observed in all the recycled coarse aggregate based woven rowing glass fiber mixes.
5) Replacement of used recycled coarse aggregate and glass fiber (volume of concrete)in concrete, the split and flexural strength was increases up to 60 % as compare to normal concrete test result.
6) The percentages of replacement of recycled coarse aggregate was increases from 0% to 60%, compressive strength strength was increases from 30% to 40% as compare to normal concrete test result.

B. Future Scope

1) For the same proportions selected in the study the effect of recycled coarse aggregate based woven rowing glass fibre on flexural and tensile strength of concrete needs further study.
2) The same experiment can be carried for different grades of concrete like M20, M30 for other w/c ratios.
3) Effect of different admixtures on woven rowing glass fiber needs to be studied.

REFERENCES

[1] Andrzej M. Brandt "Fibre reinforced cement-based(FRC) composites after over 40 years of development in building and civil engineering", march 2008, pg: 3 -9.
[2] Bashar Taha et al. "Utilizing waste recycled glass as sand/cement replacement in concrete",dec 2009.
[3] C.H. Chen et al., "Waste E-glass particles used in cementitious mixtures", dec 2005.
[4] D. Matias et al., "Mechanical properties of concrete produced with recycled coarse aggregates – Influence of the use of superplasticizers", apr 2013.
[5] Ilker Bekir Topcu et al., "Properties of concrete containing waste glass", july 2003.
[6] K.K. Sagoi et al., "Performance of concrete made with commercially produced coarse recycled concrete aggregate", nov 2000.
[7] Khaldoum Rahal "Mechanical Properties of concrete with recycled coarse aggregate", july 2005.
[8] Kiang Hwee Tan et al. "Use of waste glass as sand in mortar : Part 1 – Fresh, mechanical and durability properties", sept 2012, pg : 109-117.
[9] Nikhil gupta et al. "Effect of filler addition on the compressive and impact properties of glass fibre reinforced epoxy" Indian Academy of Sciences, January 2001, pg: 219-223.
[10] P.J.Nixon, "Recycled concrete as an aggregate for concrete –a review".
[11] P.R. Srinivasa et al., "Strength Properties Of Glass Fibre Concrete", APRN journal, vol 5,no 4, april 2010.
[12] Rama Mohan Rao et al., "Effect of Glass Fibres on Flyash Based Concrete", ijcse journal, vol 1, no 3, 2010.
[13] Suresh Babu.R, "Strength And Permeability Characteristic Of Fibre Reinforced Concrete", IJREAT, Vol 1, Issue 1, March, 2013.
[14] S.V. Joshi, "Are natural fiber composites environmentally superior to glass fiber reinforced composites",sept 2013.
[15] Tumadhir Merawi Borhan "Properties of glass concrete reinforced with short basalt fibre", feb 2012, pg:265-271.
[16] Yogesh Iyer Murthy et al, "Performance of Glass Fiber Reinforced Concrete", IJEIT,vol.1, issue 6,june 2012.
[17] M.S. Setty, "Concrete technology".