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Strength Properties of High Strength Concrete Using Recycled Concrete Aggregate

B. Suguna Rao,[1] B. Lakshmi Sravanthi[2]

[1]Faculty (Corresponding Author), Civil Engineering Department, M S Ramaiah Institute of Technology, Bangalore, Karnataka, India.

Address: C-107, Gowri Apartment, New BEL Road, Bangalore-560054

Telephone: 9611802797, **E-mail**: suguna_rao@yahoo.com

[2]M.Tech Student, Civil Engineering Department, M S Ramaiah Institute of Technology, Bangalore, Karnataka, India.

Address: C/O saguturu, ojili, spsr Nellore, Andhra pradesh-524402,

Telephone: 7204389616, **E-mail**: lakshmisravanthi73@gmail.com

Abstract

The demand for creativity and luxury over the world is increasing the demolition activities for the construction of new buildings in place of old ones. Thus huge amount of demolition wastes is being generated around the world causing a problem for its disposal. Further to meet the needs of growing construction industry there is a heavy demand for natural aggregates because of which they are getting depleted. Hence to overcome the depletion and for making a sustainable world the use of recycled aggregates came into picture. Recycled aggregates have found their use in many works like pavements, kerbs etc. but they are rarely used for engineering works. This project aims at finding the usage of recycled aggregates for high strength concrete. The present research studies the strength of concrete made with different replacement levels of natural aggregates with recycled aggregates. The replacement ratios considered are 0.54, 0.67 and 0.81. Specimens are made to find the compressive strength, tensile strength and flexural strength at different W/B ratios and different F.A to T.A ratio and thus the applicability is studied.

Key words: *recycled aggregate concrete, compressive strength , split tensile strength, flexural strength. Key factors.*

INTRODUCTION

It is pretty known fact that the usage of concrete over the world is next only to water. From this fact it can be understood that the materials used in concrete has a heavy demand in the present world. Concrete is a mixture of cement, sand, coarse aggregates and water[1,2]. The usage of cement emits greenhouse gases and the aggregates are getting depleted day by day due to continuous usage. Thus there is a need to find an alternative to control the depletion of aggregates. Also, another growing concern in the construction industry is the waste generated by demolition activities. From the studies conducted it is seen that only 30% of total waste produced due to demolition activities is being utilized in minor works and the rest is being dumped in landfills thus posing a problem to find land for its disposal. Hence to control depletion of natural aggregates and to substitute the problem of land disposal of demolished wastes the best alternative suggested by many researchers after thorough investigation is the usage of demolished waste as coarse aggregates in new construction. The aggregates made of demolished waste is termed as recycled aggregate. The usage of demolished aggregates is dated back since romans. Till now recycled aggregates are being used in many minor works like kerbs, pavements, embankment fill materials, paving blocks etc. the present research focuses on the application of recycled aggregates in major works. Hence high strength recycled aggregate concrete is studied to find its application in major works. The present research studies the strength of concrete made with recycled aggregates for different replacement ratios, water to cement ratio and fine to total aggregate ratio. Specimens are made and tested to know the compressive strength, tensile strength and flexural strength of recycled aggregate concrete of different proportions[3-5]. From the research conducted it can be said that as the replacement ratio increased the strength decreased and also the optimum ratio of fines to total aggregate for any replacement ratio is 0.4

Experimental procedure

Materials used

Cementitious materials used in this study consist of 90% Portland cement of 43 grade and 10% silica fume with a specific gravities of 3.09, and 2.22 . Crushed stone particles down size 12mm was obtained from local crushing units are used as natural coarse aggregates with a specific gravity of 2.515, recycled aggregates used for replacement of natural coarse

aggregates was obtained from demolition site inside the campus of M.S.R.I.T . A recycled aggregate of 12.5 mm down size was obtained by crushing and sieving with a specific gravity of 2.31. Manufactured sand was used as fine aggregate with a specific gravity of 2.56. Portable water was used for mixing the ingredients of concrete. CONPLAST was used to obtain required workability of concrete[6-9].

Mix design

As mix design for high strength concrete is not provided in IS 456, Mix design calculations are done based on perumals method. Portland cement was 10% replaced by silica fume.Three water /cement ratios are considered for mix design for three different replacement ratios. Replacement ratios fixation was done based on past work of Anaghakalpavali presented on paper "UTILIZATION OF DEMOLISHED CONCRETE AS COARSE AGGREGATES IN HIGH STRENGTH CONCRETE". Dosage of CONPLAST is adjusted by number of trail mixes to attain required workability and compressive strength.

Test specimens and testing

In the current study recycled aggregates obtained from demolition work going on campus were crushed manually, sieved, and washed for removal offoreign bodies to maximum possible extent.Mixes was done based on combinations of various levels of water/cement ratio at 0.27, 0.3 and 0.33, fines/total aggregate ratio at 0.35, 0.4 and 0.45 for replacement levels of 35%, 40% and 45%.Mixes were tested for workability and then test specimens of cubes, cylinders and prisms were casted. Specimens was cured for 28 days and kept for surface drying before using it for testing. Testing of cubes and cylinders can be done using compressive testing machine where as testing of prisms can be done using flexural testing machine. 9 cubes ,3 cylinders and 3 prisms was casted for each mix, a total of 243 cubes and 81 cylinders and prisms was casted fro 27 mixes(3X3X3).

Results

Compression strength test for different water to binder ratios and replacement ratios is conducted and the results are given in the below graphs. Three cubes of same mix proportions are tested at a time and the results given is the average of three cubes.

Table:1 *compressive strength test results at 28 days*

Replacement Ratio	F.A /T.A	Compressive Strength(W/C=0.27)	Compressive Strength(W/C=0.30)	Compressive Strength(W/C=0.33)
0.54	0.35	65.2	64.28	63.72
0.54	0.4	68.88	66.72	63.34
0.54	0.45	65.23	68.52	60.32
0.67	0.35	64.28	65.12	62.38
0.67	0.4	67.8	66	62.68
0.67	0.45	64.26	64.24	58.63
0.81	0.35	62.54	54.67	53.64
0.81	0.4	66	58.08	54.72
0.81	0.45	61.16	63.36	60.72

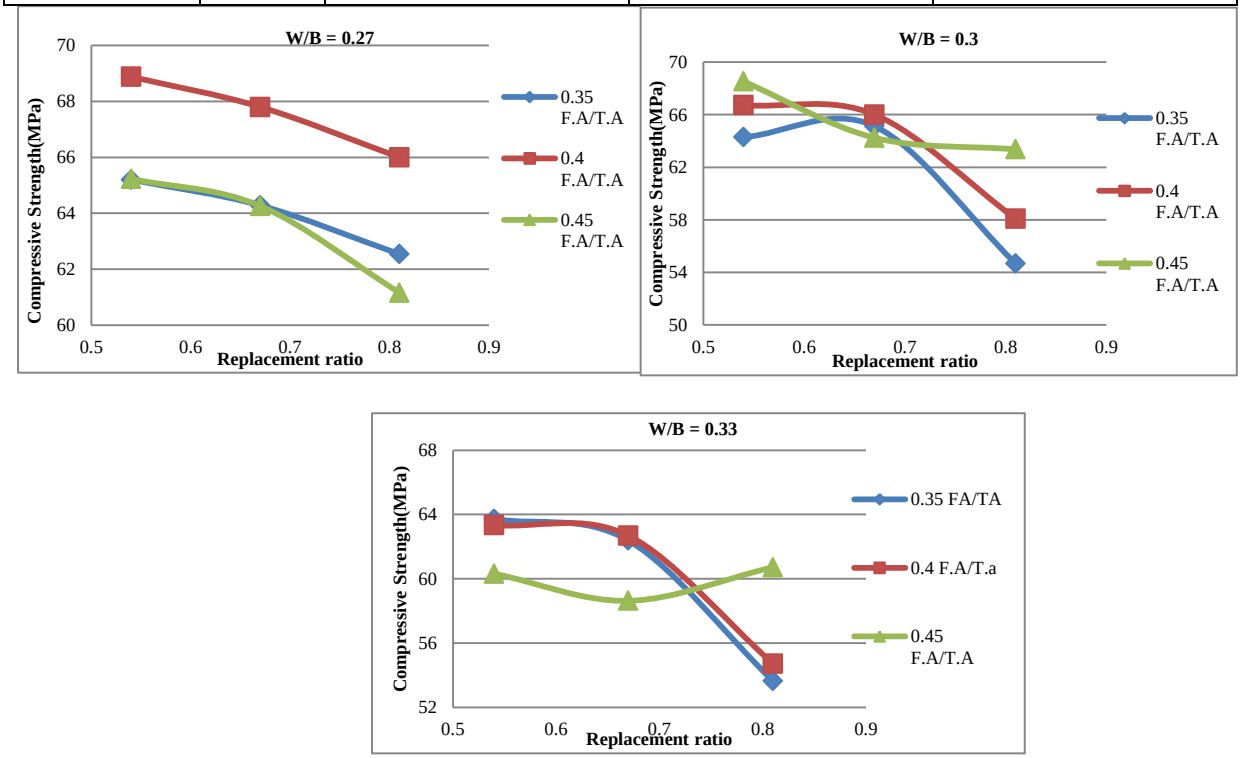

Fig1 : *Compressive strength variation with replacement ratio for different F.A/T.A*

From the above results the maximum strength (68.8MPa) is obtained for replacement ratio of 0.54 at W/B ratio of 0.27 and fines/total aggregate of 0.4. It can be observed that as the W/B ratio is increasing the strength decreased irrespective of replacement ratio and also the strength has not followed any regular pattern with the variation of fines to total aggregate ratio. For many cases the maximum strength is obtained for fines to total aggregate ratio of 0.4. However it can be incurred from the graphs that as the replacement ratio increased the strength decreases in all cases of study.

Split Tensile Test

Split tensile strength indicates the brittleness of concrete. The split tensile test results will be almost same as the true tensile strength of concrete. Cylindrical specimens of diameter 100mm and length 200mm are cast and the test is conducted in UTM at a constant rate of 10N/mm^2. The results for different mixes and proportions are given in the below table.

Table 5.2: Split tensile strength test results for 28 days

Replacement Ratio	F.A /T.A	Split Tensile Strength (mpa)(W/C=0.27)	Split Tensile Strength (mpa) (W/C=0.30)	Split Tensile Strength (mpa) (W/C=0.33)
0.54	0.35	6.52	6.42	6.4
0.54	0.4	6.88	6.6	6.3
0.54	0.45	6.52	6.8	6.03
0.67	0.35	6.42	6.51	6.23
0.67	0.4	6.82	6.6	6.32
0.67	0.45	6.57	6.42	5.8
0.81	0.35	6.2	5.56	5.36
0.81	0.4	6.6	5.8	5.52
0.81	0.45	6.06	6.26	6.17

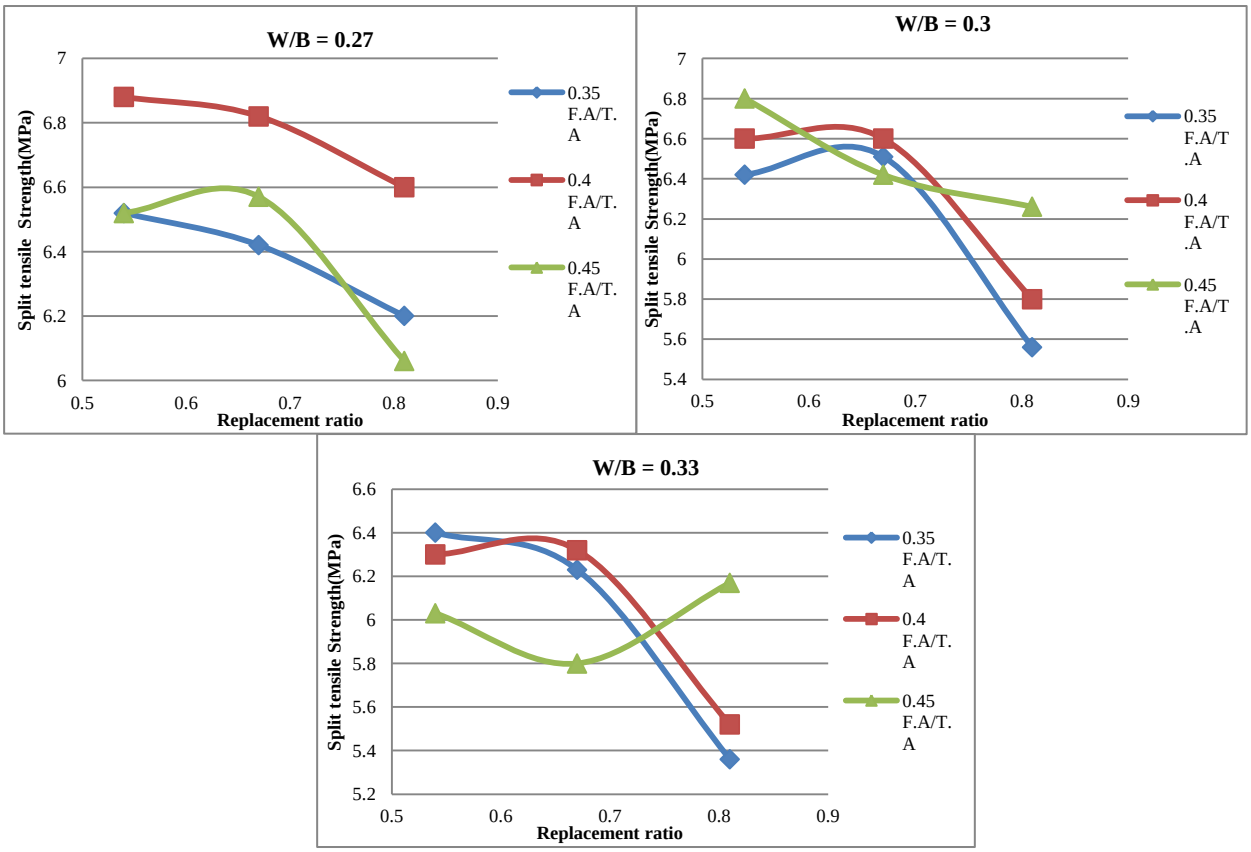

Fig 2 : *Split tensile strength variation with replacement ratio for different fines to total aggregate.*

The maximum tensile strength (6.88MPa) is obtained for 0.27 W/B ratio at fines to total aggregate ratio of 0.4 and 0.54 replacement ratio. It can be inferred from the test results that the variation is quite less for each variation in W/B ratio. Also, the variation of strength increased with increase in W/B ratio. It can be observed from the graphs that the strength decreased with increase in replacement ratio. As seen from the graph the maximum strength is obtained for replacement ratio of 0.4 in all cases.

Flexure test:

Replacement Ratio	F.A /T.A	Flexural Strength(W/C=0.27)	Flexural Strength(W/C=0.30)	Flexural Strength(W/C=0.33)
0.54	0.35	5.91	5.79	5.92
0.54	0.4	6.14	5.91	4.85
0.54	0.45	5.79	5.67	4.85
0.67	0.35	5.55	5.14	6.08
0.67	0.4	5.96	5.91	5.46
0.67	0.45	5.32	5.58	6.23
0.81	0.35	5.7	5.58	5.73
0.81	0.4	5.33	5.14	5.11
0.81	0.45	5.65	5.58	5.93

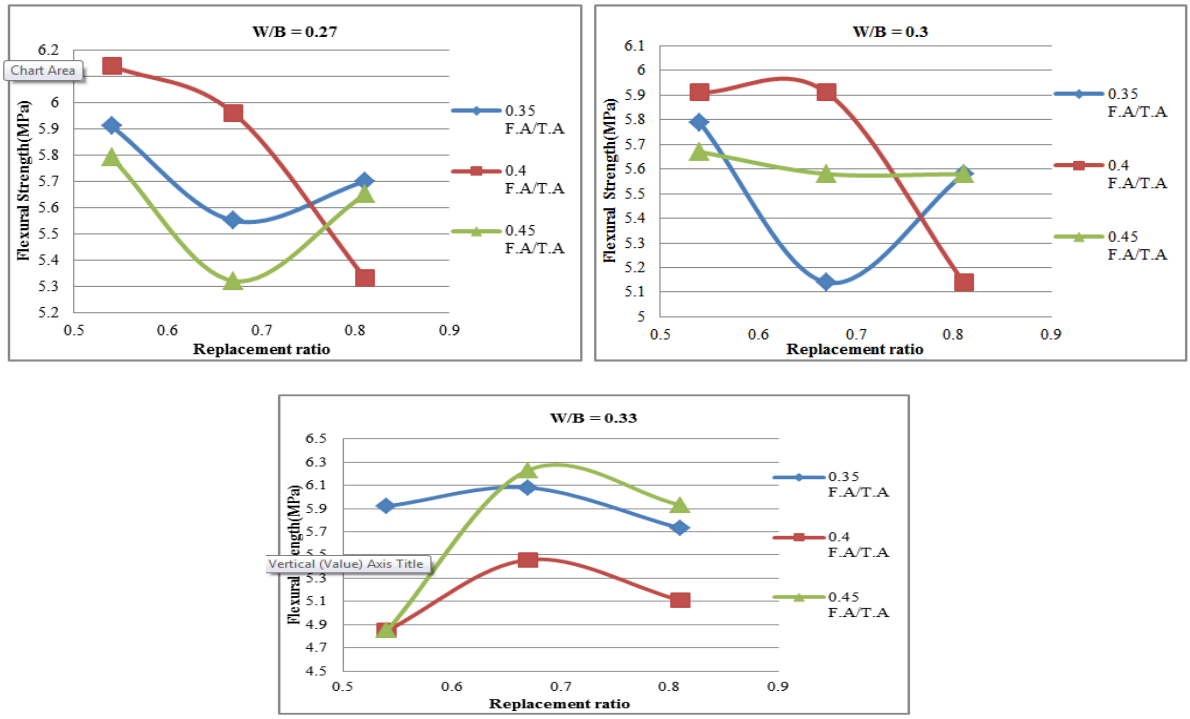

Fig 3: *Flexural strength variation with replacement ratio for different fines to total aggregate*

From the above results it can be seen that the maximum flexural strength is obtained at replacement ratio of 0.54 for W/B ratio of 0.27 at fines to total aggregate ratio of 0.4. It can be observed from the graphs that the variation of strength with different parameters has followed an irregular pattern. However as in the previous cases the maximum strength is obtained for 0.4 F.A/T.A in most of the cases.

CONCLUSIONS

- For 35%, 40%, and 45% replacements of natural aggregates with recycled aggregates maximum compressive strength can be obtained at 0.27 W/B for 0.4 fine/total aggregate ratios and at 0.3 W/B for 0.45 F.A/T.A.
- split tensile strength test results shows that for 35%, 40%, and 45% replacements of natural aggregates with recycled aggregates maximum strength can be obtained at 0.27 W/B for 0.4 fine/total aggregate ratio.
- For 35%, 40%, and 45% replacements of natural aggregates with recycled aggregates maximum flexural strength can be obtained at 0.27 W/B for 0.4 fine/total aggregate ratios.

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