EXPERIMENTAL STUDY ON REPLACING AGGREGATES BY CONCRETE WASTE

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ABSTRACT - *Preservation of the environment and conservation of the rapidly diminishing natural resources should be the essence of sustainable development. Continuous industrial development poses serious problems of construction and demolition waste disposal. Whereas on the one hand, there is critical shortage of natural aggregates (NA) for production of new concrete, on the other the enormous amounts of demolished concrete produced from deteriorated and obsolete structures creates severe ecological and environmental problem. One of the ways to solve this problem is to use this 'waste' concrete as aggregates . Such 'recycled' aggregate could also be a reliable alternative to using natural aggregates in concrete construction. Also there are instances of imposition of levy for disposal of such waste in landfill, Initially, recycling of demolitionwastewas first carried out after the SecondWorldWar in Germany. Since then, researchwork carried out in several countries has demonstrated sufficient promise for developing use of construction waste as a constituent in new concrete. Construction and Demolition (C&D) waste could be broken concrete, bricks from buildings, or broken pavement. thus Recycled Aggregate (RA) could come from the demolition of buildings, bridge supports, airport runways, and concrete roadbeds. Concrete made using such aggregates is referred to as recycled aggregate concrete (RAC). With the rapid development of urbanization, many old buildings have been demolished and a lot of construction waste is generated. Manufacturers around the world produce more than 25 billion tons of concrete each year, according to the World Business Council for Sustainable Development. The entire produced concrete will turn into waste after its design period. Among various types of materials, concrete waste accounts for about 50% of the total waste generation. One of the major challenges of our present society is the protection of environment. Some of the important elements in this respect are the reduction of the consumption of energy and natural raw materials and consumption of waste materials. These topics are getting considerable attention under sustainable development nowadays.*

1. INTRODUCTION

1.1Objective of the study

- The aim of this study is to use the demolished concrete waste as aggregate in the production of new concrete.
- To determine the mechanical properties of concrete by replacing the fine aggregate and coarse aggregate by crushed concrete waste.
- The concrete waste is collected from the local demolished structure.

1.2 International scenario of concrete waste

It has been estimated that approximately 180 million tones of Construction & Demolition waste are produced each year in European Union. In general, in EU, 500 Kg of construction rubble and demolition waste correspond annually to each citizen. Indicatively 10% of used aggregates in UK are RCA, whereas 78,000 tons of RCA were used in Holland in 1994. The Netherland produces about 14million tons of buildings and demolition wastes per annum in which about 8 million tons are recycled mainly for unbound road base courses. The 285 million tons of per annum construction waste produced in Germany, out of which 77 million tons are demolition waste. Approximately 70% of it is recycled and reused in new construction work. It has been estimated that approximately 13 million tons of concrete is demolished in France every year whereas in Japan total quantity of concrete debris is in the tune of 10-15 million tons each year. The Hong Kong generates about 20 million tons demolition debris per year and facing serious problem for its disposal.USA is utilizing approximately 2.7 billion tons of aggregate annually out of which 30-40% are used in road works and balance in structural concrete work. A recent report of Federal Highways Administration, USA refers to the relative experience from European data on the subject of concrete and asphalt pavement recycling as given in Table 3.The rapid development in research on the use of RCA for the production of new concrete has also led to the production of concrete of high strength/performance.

1.3 Indian scenario

Central Pollution Control Board has estimated current quantum of solid waste generation in India to the tune of 48 million tons per annum out of which, waste from construction industry only accounts for more than 25%. It is estimated that the construction industry in India generates about 10-12 million tons of waste annually. Management of such high quantum of waste puts enormous pressure on solid waste management system. In view of significant role of recycled construction material and technology in the development of urban infrastructure, TIFAC(Technology Information, Forecasting and Assessment Council) has conducted a techno-market survey on 'Utilization of Waste from Construction Industry' targeting housing /building and road segment. The total quantum of waste from construction industry is estimated to be 12 to 14.7 million tons per annum out of which 7-8 million tons are concrete and brick waste. According to findings of survey, 70% of the respondent have given the reason for not adopting recycling of waste from Construction Industry is "Not aware of the recycling techniques" while remaining 30% have indicated that they are not even aware of recycling possibilities. Further, the user agencies/ industries pointed out that presently, the BIS and other code provisions do not provide the specifications for use of recycled product in the construction activities

1.4 Concrete recycling

One of the problems arising from continuous technological and industrial development is the disposal of waste materials. Various solutions have been sought out for this major environmental problem and the best solution found is recycling. As a result of fast population growth and urbanization the construction industry is growing at a great pace in our country as well. Everyday old buildings are being knocked down and replaced with the new ones. The debris from these demolished buildings is thrown away, causing environmental pollution, or is used as protective barrier and ground-filling material against erosion.Recycling of construction material helps saving the limited landfill space. Recycling concrete waste as recycled aggregate is one of the methods to reduce the concrete waste. Concrete recycling is an increasingly common method of disposing of concrete structures. Concrete debris was once routinely shipped to landfills for disposal, but recycling is increasing due to improved environmental awareness, governmental laws and economic benefits. Concrete, which must be free of trash, wood, paper and other such materials, is collected from demolition sites and put through a crushing machine, often along with asphalt, bricks and rocks. Reinforced concrete contains rebar and other metallic reinforcements, which are removed with magnets and recycled elsewhere. The remaining aggregate chunks are sorted by size. Larger chunks may go through the crusher again. Smaller pieces of concrete are used as gravel for new construction projects. Aggregate base gravel is laid down as the lowest layer in a road, with fresh concrete or asphalt placed over it. Crushed recycled concrete can sometimes be used as the dry aggregate for brand new concrete if it is free of contaminants, though the use of recycled concrete limits strength and is not allowed in many jurisdictions.

1.5 Manufacture of concrete waste

By far the most common method for recycling dry and hardened concrete involves crushing. Mobile sorters and crushers are often installed on construction sites to allow on-site processing. In other situations, specific processing sites are established, which are usually able to produe higher quality aggregate. Sometimes machines incorporate air knives to remove lighter materials such as wood, joint sealants and plastics. Magnet and mechanical processes are used to extract steel, which is then recycled. Closed circuit wet washing systems, in addition to crushing, are also sometimes used to recover purer products and/or to allow the reuse of the fines. A typical crusher system is represented below:

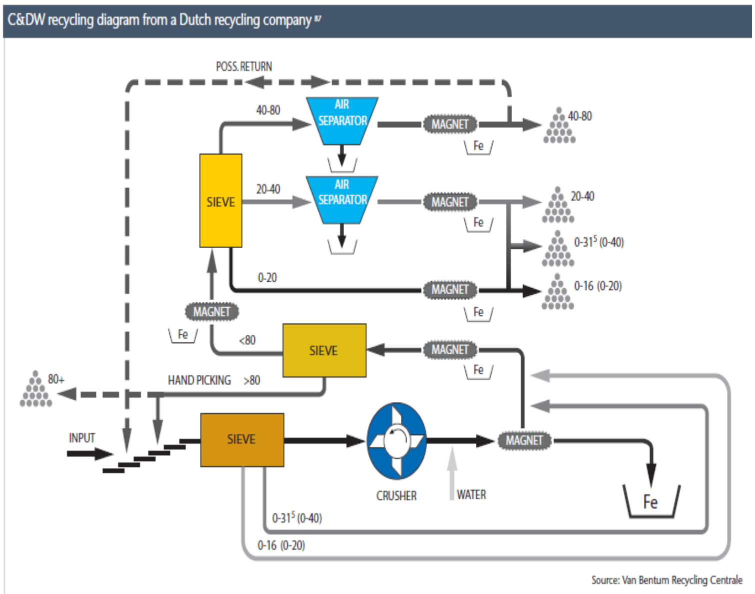

Figure 1.1 Concrete Crusher System

1.6 Comparison of Crusher Types

Table No.1.1 Comparison Of Crushers

Type	Advantage	Disadvantage	Applications
Semi-mobile and mobile with jaw crusher	•Simple, rugged construction •Low wear •Crushes hardest rocks	•Lower crushing efficiency •Problems with crushing bituminous broken road paving •Recycling of oversize practically impossible	Crushing of unproblematic building rubble where no demands are placed on product quality or capacity
Semi-mobile and mobile with impactor	•Favorable crushing efficiency with all types of building rubble and broken road paving	•Relatively high wear rate •Could generate excessive fines	Suitable for all-round rubble crushing with a high capacity
Stationary plant with jaw crusher and impactor or 2 impactors	•Combines advantages of both crusher types •High capacity •Can crush large-size reinforced concrete waste	•Plugging problems with bituminous material •High capital costs	Good for high capacities combined with high demands on product quality
•Stationary plant with jaw and cone crusher **Type**	•Very good product quality, sharp, cubical form •Low wear rate **Advantage**	•Susceptible to rebars and tramp metal in cone crusher •High capital costs **Disadvantage**	Recommended for generation of high quality secondary raw materials **Applications**
•Stationary plant with beater drum and impactor	•Particularly good for handling large concrete lumps	•Very high wear •High capital costs	Ideal combination for recycling concrete waste, railway sleepers, concrete masts, etc.

2. MATERIAL PROPERTIES

2.1 MATERIALS USED

2.1.1 Cement

Figure 2.1 Cement

Ordinary Pozzolana Cement was used in casting the specimens. The Specific Gravity, Fineness, Initial setting time and Consistency of the cement were tested.

Table 2.1 Properties of Cement

S.No.	Description	Value
1.	Specific gravity	3.15
2.	Fineness (by sieve analysis)	2%
3.	Consistency	32%
4.	Initial setting time	52 minutes
5.	Final setting time	372 minutes

2.1.2 Coarse Aggregate

Figure 2.2 Coarse Aggregate

Hard granite broken stones of less than 20mm size were used as coarse aggregate. The Specific Gravity, Fineness modulus, Water absorption and Bulk density of the coarse aggregate were tested.

Table 2.2 Properties of Coarse Aggregate

S.No.	Description	Values
1.	Specific gravity	2.75
2.	Bulk density	1648.73 Kg/m^3
3.	Water absorption	1%
4.	Fineness modulus	4.67
5.	Average Impact Value	15.79%
6.	Average Crushing value	20.8%

2.1.3 Fine Aggregate

Figure 3.2 Fine Aggregate

River sand of size less than 4.75 mm size were used as fine aggregate. The Specific Gravity, Fineness modulus, Water absorption and Bulk density of the fine aggregate were tested.

Table 2.3 Properties Of Fine Aggregate

S.No.	Description	Values
1.	Specific gravity	2.69
2.	Bulk density	1632.19 Kg/m^3
3.	Water absorption	1%
4.	Fineness modulus	2.72

2.1.4 Water

Potable water available in laboratory with pH value of of not less than 6 and conforming to the requirement of IS 456-2000 was used for mixing concrete and curing the specimen as well.

2.1.5 Properties of Concrete Waste

Table 2.4 Properties of Concrete Waste

S.No.	Description	Values
1.	Specific gravity of RFA	2.5
2.	Specific gravity of RCA	2.6
3.	Average impact value	19.6%
4.	Average crushing value	28.4%

2.1.6 Fibre – Fibrillated Polypropylene Fibre

Fig 2.4 Polypropylene Fibre

- Material – Virgin Homo polymer polypropylene
- Length – 12 mm, 19 mm, 38 mm.
- Form – Collated Fibrillated Fibre.
- Color – White
- Specific gravity – 0.91
- Acid/Alkali resistance – Excellent

- Tensile strength – 620 to 758 MPa
- Absorption – Nil
- Minimum fibre content – 0.9 kg/m^3 of concrete
- Melting point – 324 ^{0}F (162.22 ^{0}C)
- Young's modulus – 3.5 kN/mm^2

2.2 Aspect Ratio:

Table 2.5 Properties Of Polypropylene Fibre

S.No.	% of Cement to Add Polypropylene Fibre	Compressive Strength on cube	Split Tensile Strength on cylinder	Flexural Strength on beam
1	10	0.42	0.84	0.84
2	20	0.84	1.26	1.26
3	30	1.26	2.52	2.52

3. MIX DESIGN

3.1 MIX DESIGN (based on IS 10262-2009)

Mix design is the process of selecting suitable ingredients of concrete and determining their relative proportion with the object of producing concrete of certain minimum strength and durability as economically as possible. The mix design is carried out to achieve specified age, workability of fresh concrete and durability requirements by using IS 10262-2009. The following data are required for mix proportioning of a particular grade of concrete.

- Grade designation : 25 N/mm^2
- Type of cement : OPC 53 Grade Cement
- Maximum nominal size of aggregate : 20 mm
- Specific gravity of fine aggregate : 2.69
- Specific gravity of coarse aggregate : 2.8
- Degree of workability : 0.9 compaction factor
- Maximum water-cement ratio : 0.375
- Exposure conditions : mild
- Type of aggregate : Crushed angular aggregate

3.1.1 Target Mean Strength

The target mean strength is determined by using the relation $f_t = f_{ck} + kS$

Where f_t - target mean compressive strength at 28 days

f_{ck} – characteristic compressive strength at 28 days

S – Standard deviation

K – Statistical coefficient

$f_t = 25 + 4.2\ (1.64) = 31.72$ N/mm^2

3.1.2 Water-Cement Ratio

Corresponding to this target mean strength, the water cement ratio is read from the appropriate curve in IS10262. Hence a water-cement ratio of 0.44 is accepted.

Water cement ratio= 0.375 (IS 10262-2009)

For mild exposure, w/c=0.55

The lesser is 0.375

The water content is 188.80 litres/m^3

The cement content works out to be 188.8/0.44 = 503.00 kg/ m^3

3.1.3 Determination Of Quantities Coarse And Fine Aggregates

Now quantities of coarse and fine aggregates are worked out per m^3 of concrete as given below:

Volume of concrete = 1 - 0.02 (Entrapped air)

= 0.98 m^3 = 980 liters

The quantity of fine aggregate is found using the equation

$$V = (w + \frac{C}{Sc} + \frac{1}{p}\frac{fa}{Sfa})\frac{1}{100}$$

$$0.98 = (188.79 + \frac{503}{3.15} + \frac{1}{0.35}\ x\ \frac{fa}{2.68})$$

f_a = 673.27 kg/m^3

Similarly, for coarse aggregates,

$$V = (w + \frac{C}{Sc} + \frac{1}{(1-p)}\frac{Ca}{Sca})\frac{1}{100}$$

$$0.98 = (188.79 + \frac{503}{3.15} + \frac{1}{(1-0.35)}\frac{Ca}{2.68})\frac{1}{100}$$

c_a = 1250.27 kg/m^3

3.1.4 Mix Proportion

Table 3.6 Mix Proportion Details

Water	Cement	Fine Aggregates	Coarse Aggregates
188.79	503.00	673.27	1250.27
0.41	1	1.338	2.48

4. EXPERIMENTAL INVESTIGATION

4.1 GENERAL

Production of good quality concrete requires meticulous care exercised at every stage of manufacture of concrete. It is interesting to note that the ingredients of bad concrete are the same. If meticulous care is not exercised and good rules are not observed, the resultant concrete is going to be of bad quality. With the same material if intense care to exercise control at every stage it will in good concrete. The various stages of manufacture of concrete are in this chapter.

4.2 TESTS ON FRESH CONCRETE

4.2.1 General

Fresh concrete or plastic concrete is a freely mixed material which can be moulded into any shape. The relative quantities of cement, aggregates and water mixed together, to control the properties of cement in wet and the hardened state.

4.2.2 Slump Test

Slump test is the most commonly used method of measuring workability of concrete. The apparatus for conduction the slump test consists of a metallic mould in the form of a frustum of a cone having the internal dimensions as follows

Bottom Diameter : 20 cm

Top Diameter : 10 cm

Height : 30 cm

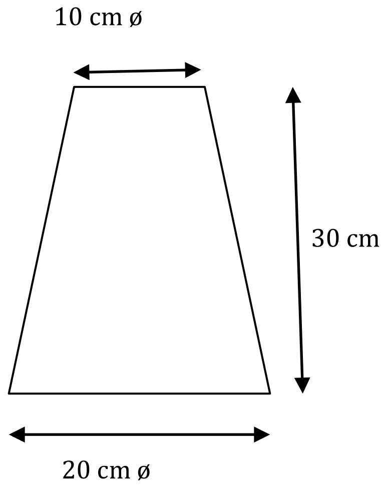

Fig 4.1: Slump apparatus

The mould is filled with concrete in four layers. Each layer is tamped 25 times by the tamping rod taking care to distribute the strokes evenly over the cross section. The mould is removed from the concrete by raising it slowly and carefully in a vertical direction. The difference in level between the height of the mould and height of subsided concrete is noted and it is taken as slump value. The slump tests conducted shows slump value of 70 mm. The medium degree of workability is obtained from the test result.

4.2.3 Compaction Factor test:

The sample of concrete to be tested is placed on the top hopper upto the brim. The trap door is opened so that the concrete falls into the lower hopper. Then the trap door of the bottom hopper is opened and the concrete is allowed to fall into the cylinder. The excess concrete remaining above the top level of the cylinder is then cut off with the help of plane blades supplied with the apparatus. The outside of the cylinder is wiped clean. The concrete is exactly filled upto the top level of the cylinder and is weighed to the nearest 10 grams. This weight is known as “Weight of partially compacted concrete”. The cylinder is emptied and then refilled with the concrete from the same sample in layers approximately 5 cm deep. The layers are heavily rammed or preferably vibrated so as to obtain full compaction. The top surface of the fully compacted concrete is then carefully struk off level with the top of the cylinder and weighed to the nearest 10 grams. This weight is known as “Weight of fully compacted concrete”.

$$\text{Compaction factor} = \frac{\text{Weight of partially compacted concrete}}{\text{Weight of fully compacted concrete}}$$

4.3 CASTING OF TEST SPECIMENS

4.3.1 Preparation of the Mould

The compressive strength of the concrete was determined by cubes of size 150mmx150mmx150mm. Split tensile strength of the concrete was determined by the cylinder of size 150mm diameter and 300mm height.

4.3.2 Mixing Of Concrete

Thorough mixing of materials is essential for the production of uniform concrete. The mixing should ensure that the mass becomes homogeneous, uniform in colour and consistency. As the mixing cannot be thorough, it is desirable to add 10% more materials. The mixing was done with tilting drum. Initially, water is poured into the mixer and then cement, fine aggregate, coarse aggregate is dumped into the drum. Allow the drum to rotate for few rotations and then bacteria is added to the concrete. Rotate the drum continuously till the mix become homogeneous.

4.3.3 Casting Of Specimen

Cube moulds of size 150mm x 150mm x 150mm and cylinder moulds of size 150mm ø and height 300mm were used for casting the concrete. The fresh mix of concrete was poured into the mould and the top surface was finished smooth with trowel.

4.3.4 Pouring Of Concrete

The homogeneous concrete mix in drum is discharged on a dry platform. On the course of time, the moulds are cleaned and applied with thin film of oil. The fresh concrete is filled in 15 cm x 15 cm x 15 cm mould in three layers of 5 cm depth. Each layer is compacted with tamping rod uniformly with 25 blows. The tamping rod used is 16 mm diameter and 600 mm long and end is bullet pointed. The purpose of compaction is to avoid entrapped air inside the concrete cubes and honey combing effects on the sides. After the top layer has been compacted, a strike off bar is used to strike out the excess concrete. During pouring of concrete, is better to avoid wasting of concrete for effective and economical usage.

4.3.5 Demoulding

The cube specimens are demoulded after 24 hours from the process of moulding. If the concrete has not achieved sufficient strength to enable demoulding the beam specimens, then the process must be delayed for another 24 hours care should be taken not to damage the specimen during the process because, if any damage is caused, the strength of the concrete may get reduced. After demoulding, specimen is marked with a legible identification, on any of the faces by using paint.

4.3.6 Curing

The concrete specimens were placed in a curing tank after demoulding. Then the specimens are taken out of the curing tank after curing and tested.

4.4 TESTS ON HARDENDED CONCRETE

4.4.1 Compressive Strength

Compressive test are made at recognized ages of the test specimens. Least three specimens, preferably from different batches shall be made for testing at each selected age. The cubes are placed in the compression testing machine in such manner that the load is applied to the opposite sides of the cube as cast. The load is applied at the rate of 140 $kg/cm^2/min$ (approximately) until the failure of the specimen.

Compression test was carried out on the specimens after 14^{th} and 28^{th} of curing and the values are tabulated in table 4.1. The compressive strength calculated and given in table 4.2(a), (b), (c) and (d)

$$F_C = P/A$$

Where, F_c = Compressive Strength (N/mm^2)

P = Ultimate Load (N) and

A = Loaded Area (150mm x 150mm)

Fig 4.2. Compression Testing machine

4.4.2 SPLIT TENSILE STRENGTH TEST

The tensile strength of concrete is determined by splitting the cylinder across the vertical diameter. Split tensile strength is an indirect method of finding out the tensile strength of concrete. As per ASTM ,the test was carried out by placing a cylindrical specimen horizontally between the loading surfaces of a compression testing machine. The load was applied until the specimen fails.

The split tensile strength is calculated using the formula

$$F=2P/\Pi dL$$

Where, P=applied load, D=diameter of rhe specimen, L=length of the specimen

4.4.3 FLEXURAL STRENGTH TEST

The standard size of the specimens 10 x 10 x 50 cm is used. The mould should be made of metal or cast iron, with sufficient plate thickness to prevent spreading or warping. The testing machine may be of sufficient capacity for the testing and rate of loading as specified. The load is applied through the roller placed at middle(central point load). The flexural strength of specimen is expressed as modulus of rupture, f_b.

Flexural strength, $f_b = 1.5P \times l / (bd^2)$

Where, P = Applied load

l = Length of specimen

b,d = Cross section dimensions of specimen.

Fig 4.3. Split Tensile Strength Testing machine

Fig 4.4 Flexural Strength Testing machine

5. RESULTS AND DISCUSSIONS

5.1 General:

The result of the investigations carried out for finding out compressive strength ,split tensile strength, flexural strength using concrete waste as fine aggregate and coarse aggregate

5.2 Tests on fresh concrete:

5.2.1 Workability

Table 5.1: Slump value for Recycled aggregate concrete

% of RA replacement	Slump mm, for RFA replacement	Slump mm, for RCA replacement
0	72	72
10	72	71
20	71	69
30	71	68
40	70	67
50	69	66
75	68	65
100	67	64

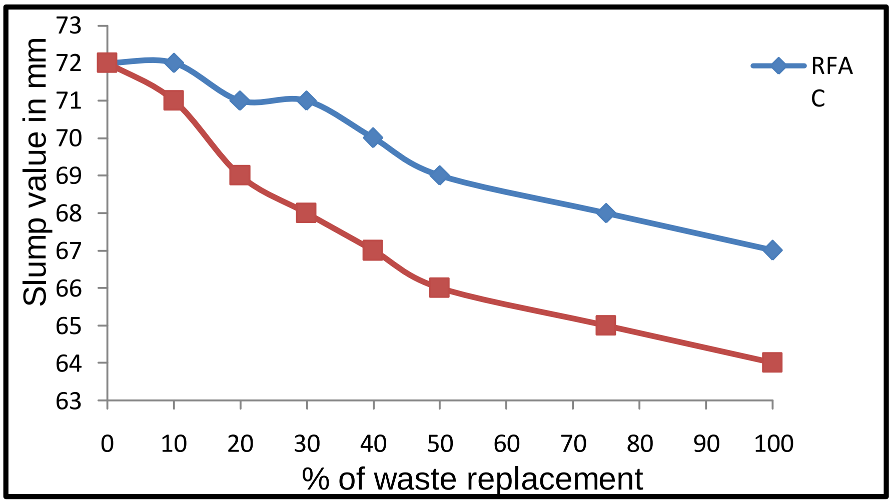

Fig 5.1:Slump values of RFA and RCA concrete

The workability was found to be in the decreasing order for RFA and RCA concrete It may due to the absorption of water by the recycled aggregate

5.3 Tests on hardened concrete

5.3.1 Compressive strength

Table 5.2: Compressive strength for RFA concrete

% of RA replacement	FA replaced by RFA		CA replaced by RCA	
	7 day	28 day	7 day	28 day
0	21.58	33.7	21.9	33.7
10	21.13	32.5	21.2	32.6
20	20.34	31.3	20.4	31.3
30	19.76	30.4	19.3	29.7
40	19.18	29.5	18.1	27.8
50	18.65	28.7	16.9	25.9
75	18.33	28.2	15.8	24.3
100	17.75	27.3	14.9	21.8

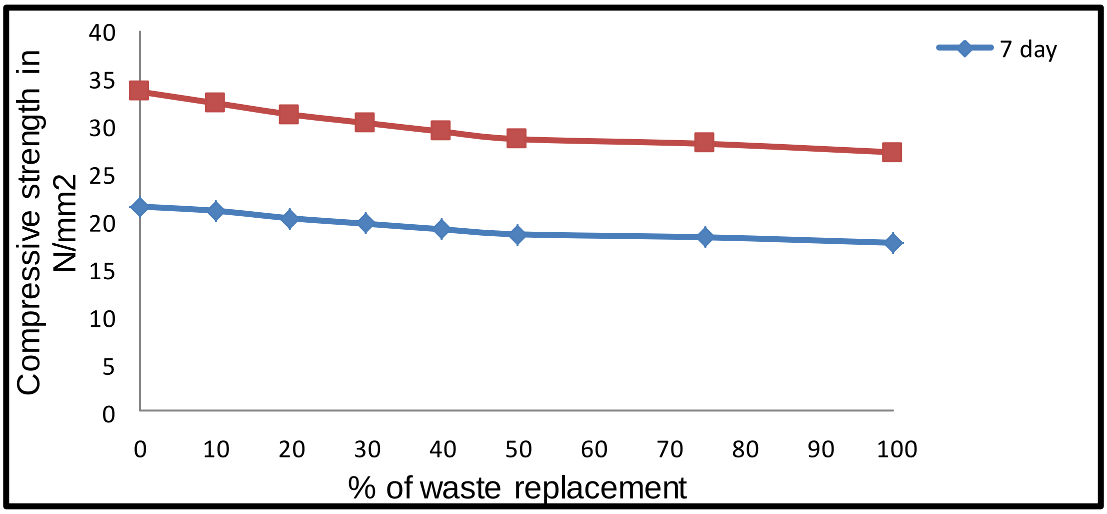

Fig 5.2 Compressive strength results for RFA replaced concrete

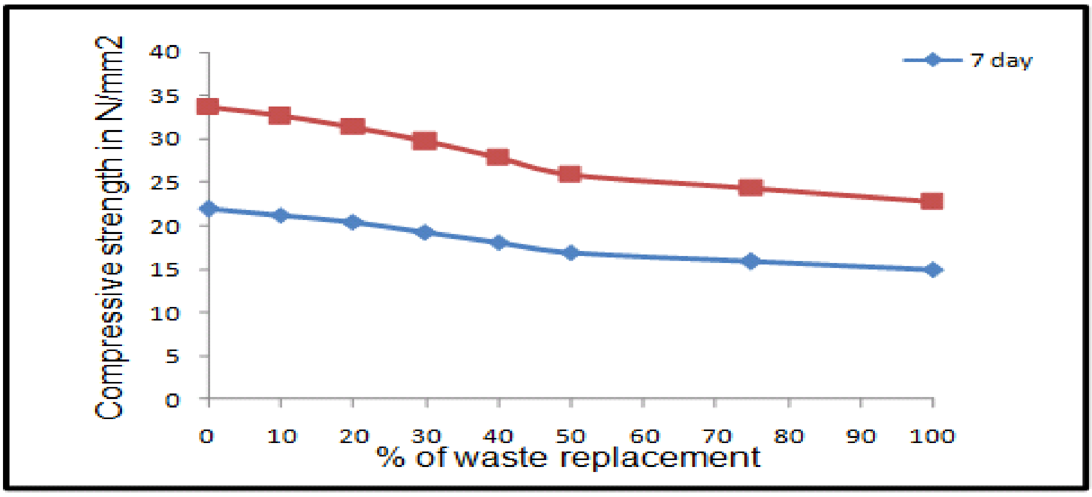

Fig 5.3: Compressive strength results for RCA replaced concrete

The compressive strength of concrete in which the fine aggregate is replaced with RFA decreases when the percentage of RFA increases and also the compressive strength of concrete in which the coarse aggregate is replaced with RCA decreases when the percentage of RCA increases.

5.3.2 Split tensile strength

Table 5.3: Split tensile strength for RFA and RCA concrete

% of waste replacement	FA replaced by Concrete waste		CA replaced by Concrete waste	
	7 days	28 days	7 days	28 days
0	2.83	3.9	2.83	3.9
10	2.71	3.82	2.6	3.7
20	2.6	3.75	2.47	3.65
30	2.535	3.67	2.34	3.5
40	2.41	3.54	2.23	3.41
50	2.36	3.42	2.15	3.24
75	2.24	3.34	2	3.1
100	2.17	3.23	1.89	2.8

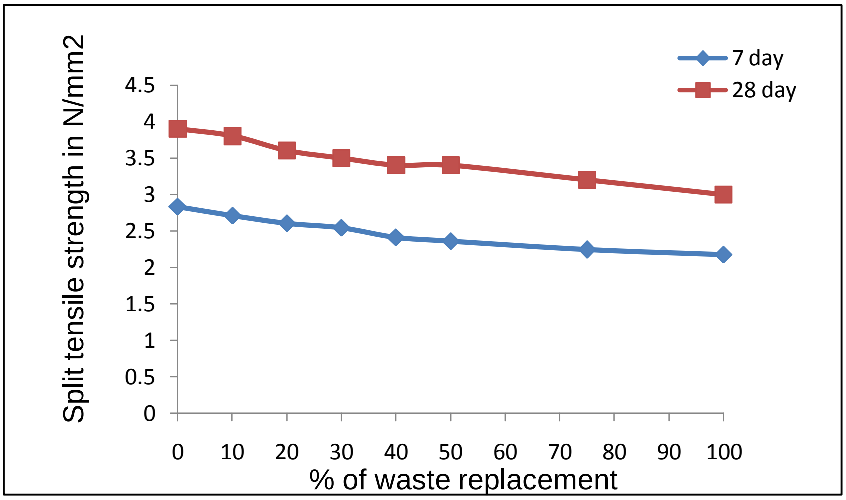

Fig 5.4: Split tensile strength for FA replacement

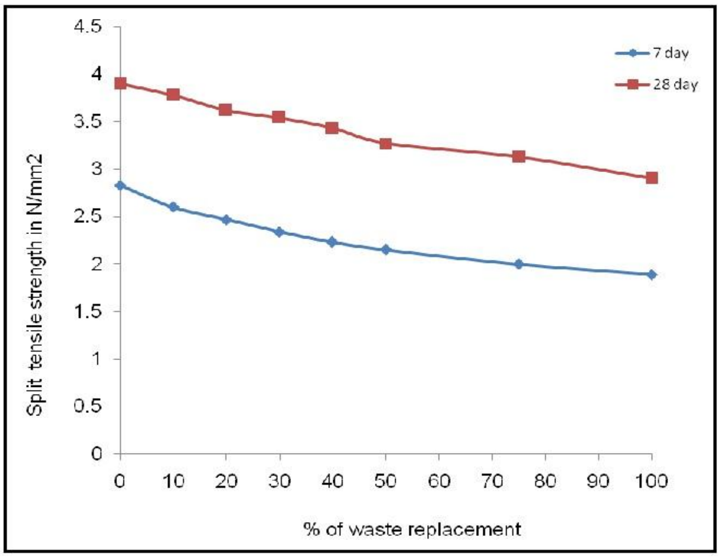

Fig 5.5: Split tensile strength for CA replacement

The split tensile strength of concrete in which the fine and coarse aggregate is replaced by RFA and RCA respectively decreases when the percentage of RA in concrete increases .

5.3.3 Flexural strength

Table 5.4: Flexural strength for RFA and RCA concrete

% of waste replacement	FA replaced by Concrete waste		CA replaced by Concrete waste	
	7 days	28 days	7 days	28 days
0	2.31	3.56	2.31	3.56
10	2.223	3.42	2.21	3.4
20	2.125	3.36	2.145	3.3
30	2.05	3.3	2.112	3.25
40	2.02	3.21	2.04	3.17
50	1.92	3.18	1.989	3.06
75	1.86	3.12	1.885	2.9
100	1.82	3.05	1.755	2.7

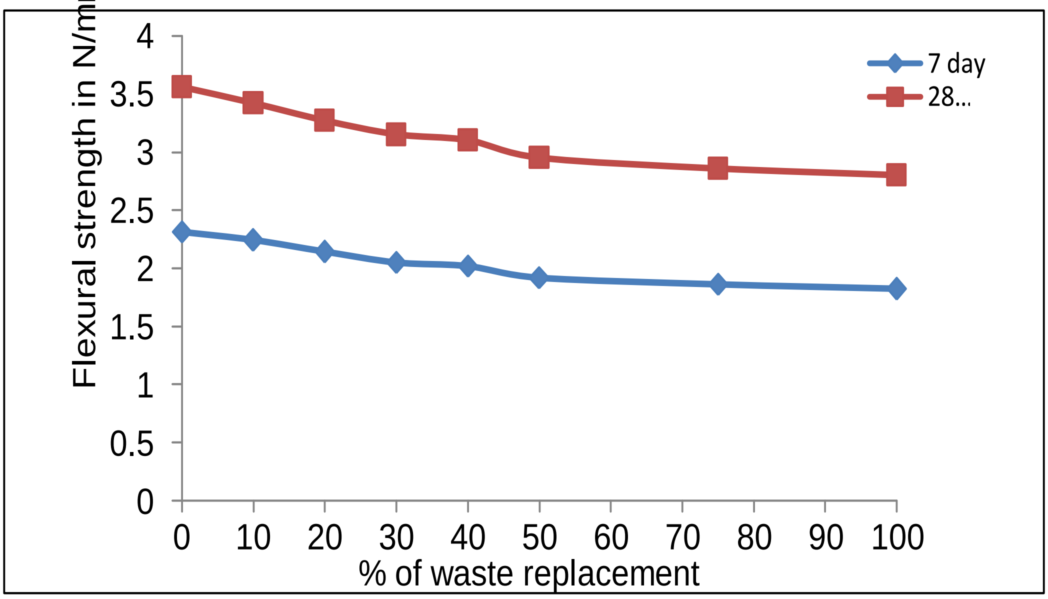

Fig 5.6: Flexural strength for FA replacement

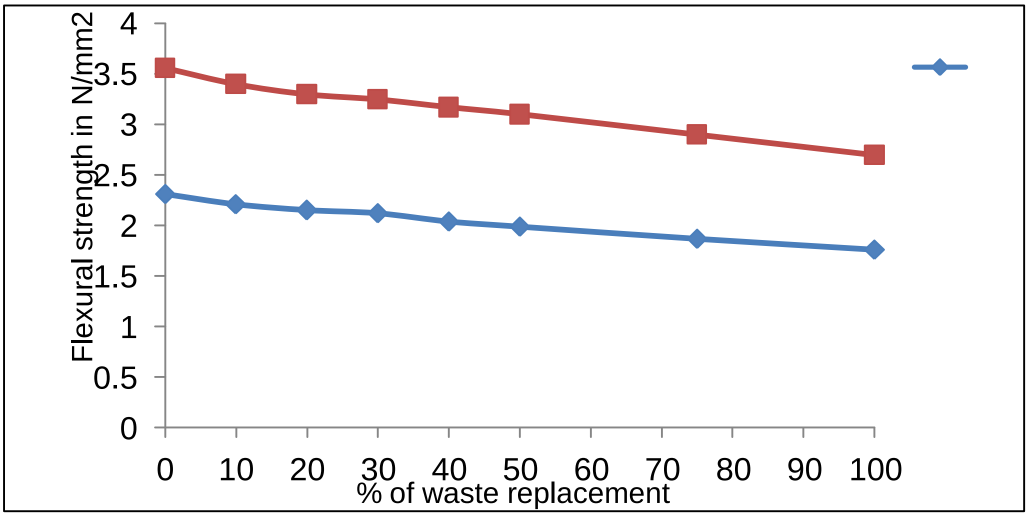

Fig 5.7 Flexural strength for CA replacement

The flexural strength of concrete in which the fine and coarse aggregate is replaced by RFA and RCA respectively decreases when the percentage of RA in concrete increase.

5.3.4 Concrete with both RFA and RCA:

Table 5.5: Strength results for both RFA and RCA replacement

% of waste replacement	28th day compressive strength	28th day Split strength	28th day flexural strength
0%	33.7	3.9	3.4
50% RFA + 50% RCA	26.6	3.5	3.1
100% RFA + 100% RCA	24.6	3.3	2.8

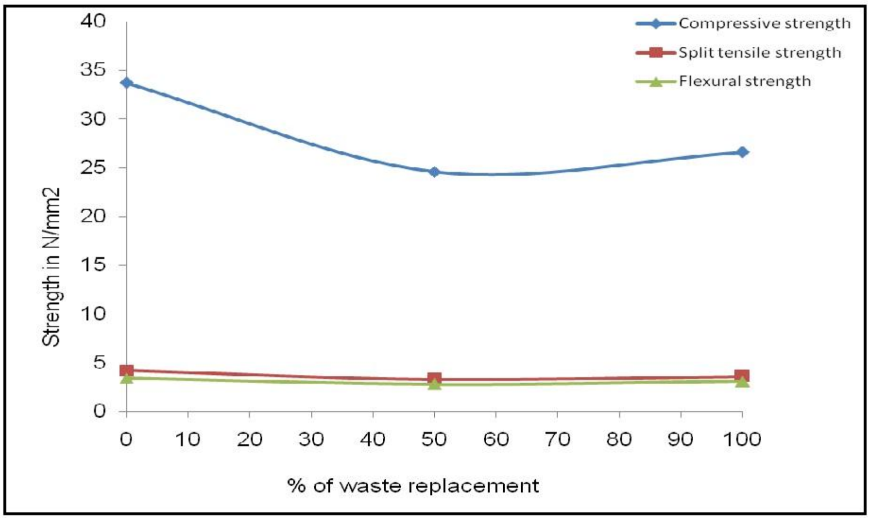

Fig 5.8: Strength results for both RFA and RCA replacement

.The compressive strength,Split tensile strength and flexural strength is found to be increased for fully replaced RFA and RCA concrete .

5.3.5 Fully replaced RAC with Polypropylene fibres:

Table 5.6 :Strength results for both RFA and RCA replacement with PP fibres

% of waste replacement	28th day compressive strength	28th day Split strength	28th day flexural strength
100% RFA + 100% RCA	26.6	3.5	3.1
100% RFA + 100% RCA with PP fibres	28.4	3.78	3.4

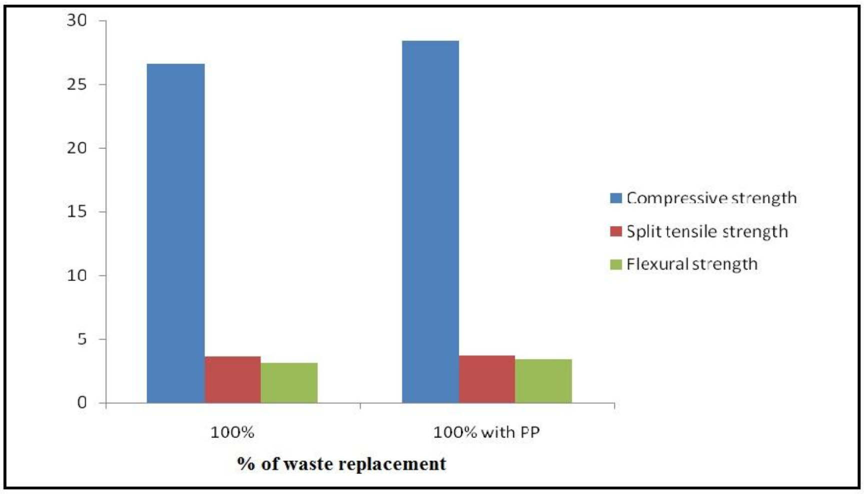

Fig 5.9: Strength results for both RFA and RCA replacement with PP fibres

The compressive strength , Split tensile strength and flexural strength is found to be increased for fully replaced RFA and RCA concrete added with polypropylene fibres.

5.4 Discussions:

1.The workability was found to be in the decreasing order for RFA and RCA concrete.It may due to the absorption of water by the recycled aggregate

2.The compressive strength of concrete in which the fine aggregate is replaced with RFA decreases when the percentage of RFA increases and also the compressive strength of concrete in which the coarse aggregate is replaced with RCA decreases when the percentage of RCA increases.

3.The split tensile strength of concrete in which the fine and coarse aggregate is replaced by RFA and RCA respectively decreases when the percentage of RA in concrete increases .

4. The flexural strength of concrete in which the fine and coarse aggregate is replaced by RFA and RCA respectively decreases when the percentage of RA in concrete increase.

5.The compressive strength,Split tensile strength and flexural strength is found to be increased for fully replaced RFA and RCA concrete .

6.The compressive strength , Split tensile strength and flexural strength is found to be increased for fully replaced RFA and RCA concrete added with polypropylene fibres.

7.The specific gravity of WCAs was slightly lower than that of normal crushed aggregates. The reason for this was thought to be the fact that there was a certain proportion of mortar over these aggregates.

8.Impact and Crushing values shows that the WCA shows considerable resistance against impact and gradual loads and these values are within the permissible limit to be used in the wearing surfaces.

6. CONCLUSION

Tests have been conducted for the prepared RAC and the results have been verified. The test results for the RAC and conventional concrete have been examined and compared. It is to be concluded that the compressive strength, split tensile strength and flexural strength are in the decreasing order when the percentage of RA replacement increases. The workability was found to be decreased by 7% and 12% for RFA and RCA respectively .The compressive strength was found to be decreased by 19% and 35% for RFA and RCA respectively. The split tensile strength was found to be decreased by 17% and 26 % for RFA and RCA respectively. .The flexural was found to be decreased by 15% and 22% for RFA and RCA respectively. The compressive strength, split tensile strength and flexural strength for fully replaced RFA and RCA was increased by 21% ,7.6% , 8.8% respectively compared to normal concrete. The compressive strength, split tensile strength and flexural strength of RAC concrete with polypropylene fibres was increased by 7% ,8.1% , 11% respectively compared to fully replaced RFA and RCA concrete. Before using the WCA it should be cleaned from the other materials carefully to get rid of debris Concrete produced by RCA does not perform as well as concretes produced by CA in terms of strength. However, the concrete still has a strength that would make it suitable for minor construction and structural works. Use of recycled aggregates in concrete provides a promising solution to the problem of C&D waste management. The compressive strength , Split tensile strength and flexural strength is found to be increased for fully replaced RFA and RCA concrete added with polypropylene fibres. In conclusion, recycling WCAs in concrete production may help solve a vital environmental issue apart from being a solution to the problem of inadequate concrete aggregates in concrete.

7. REFERENCES

1. Aggregates for Concrete, Developed by American Concrete Institute (ACI) Committee E-701, First Printing August 2007

2. Chemical–mineralogical characterisation of coarse recycled concrete aggregate M.C. Limbachiya , E. Marrocchino , A. Koulouris, Waste Management 27 (2007) 201–208.

3.“Concrete Mix Proportioning – Guidelines”, First Revision, July, 2009, IS 10262:2009.

4. Influence of amount of recycled coarse aggregates and production process on properties of recycled aggregate concrete , M. Etxeberria, E. Vázquez, A. Marí and M. Barra (2007), Cement and Concrete Research, Vol.37(5), pp.735–742.

5. Local Construction And Demolition Waste Used As Coarse Aggregates In Concrete” Madan Mohan Reddy.K, Bhavani.R and Ajitha. B, International Journal of Engineering Research, Vol. 2, Issue 5, September- October 2012, pp.1236-1238

6. Leaching and mechanical behaviour of concrete manufacturedwith recycled aggregates D. Sani, G. Moriconi, G. Fava , V. Corinaldesi, Waste Management 25 (2005) 177–182

7. Methods of sampling and test (physical and chemical) for water used in industry, IS 3025:1964.

8. Physical and mechanical properties of concretes produced with waste concrete, i.B. Topqu, Cement and Concrete Research, Vol. 27, No. 12, pp. 1817-1X23, 1997

9. Properties of concretes produced with waste concrete aggregate,Ilker Bekir Topcu Selim S_engel, Cement and Concrete Research 34 (2004) 1307–1312

10. Recycled aggregate concrete (RAC) methodology for estimating its long-term properties, Jorge de Brito & Ricardo Robles (2010), , INDIAN J. ENG. MATER. SCI., pp.449-462

11. Recycling and reuse of waste concrete in China Part II. Structural behaviour of recycled aggregate concrete and engineering applications, Xuping Li , Resources, Conservation and Recycling 53 (2009) 107–112

12. Specification for 53 grade Ordinary Portland Cement, Bureau of Indian Standard, New Delhi, IS 12269:1987.

13. “Specification for Coarse aggregate and Fine aggregate from Natural Sources for Concrete”, Bureau of Indian Standard, New Delhi, IS 383:1970.

14. Short and long-term behavior of structural concrete with recycled concrete aggregate S. Manzi , C. Mazzotti, M.C. Bignozzi, Construction and Building Materials 23 (2000) 150-155