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Research Article

BEHAVIOR OF CONVENTIONAL CONCRETE INCORPORATING CLASS F-FLY ASH AND RECYCLED AGGREGATES

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ABSTRACT

Varieties of waste materials are produced from construction industries, thermal power generating factories etc., impacts and pollute environment. The bulk of this waste remains unutilized. There is increasing shortage of building materials which can be met by producing durable alternative from these wastes. The purpose of this study is based on the investigation of conventional concrete incorporating with class F-fly ash and recycled aggregates to reduce the use of cement and natural aggregates need. The cementitious material content was maintained constant at 383 kg/m^3, fine aggregate of 564 kg/m^{3,} coarse aggregate of 1142 kg/m^3 and the water/cementitious ratio of 0.48. Conventional Concrete mixture had a replacement of 20% by class F-fly ash and 100% recycled aggregates by volume. Tests were carried out on fresh concrete in terms of viscosity and workability. And the mechanical properties of hardened concrete such as compressive strength were also determined. The sustainable Conventional Concrete (with 20% class F-fly ash & recycled aggregates) developed a lesser 14 and 28-days compressive strength compared with M20 graded Conventional Concrete (with 100% cement & natural aggregates). This paper briefly explained about the preparation of mixtures test methods, comparative discussion and the conclusion based on the test results.

INTRODUCTION

In Construction industry concrete is the most widely used material because of its mould ability into any required structure form and shape due to its fluidity at early stage. The word concrete comes from the Latin word 'concretus' (meaning compact or condensed), the perfect passive participle of 'concrescere', from 'con'- (together) and'crescere' (to grow).

Development of new types of concrete with improved performance is a very important issue for the whole building industry. This development is based on the optimization of the concrete mix design, with an emphasis not only to the workability and mechanical properties but also to the durability and the reliability of the concrete structures in general. Appearance of the new types of concrete requires a revision and improvement of existing structural system and actual building technologies. The economical aspects are of important as well.

CONCRETE

Concrete is a composite material composed of coarse granular material (the aggregate or fillers) combined

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in a hard matrix of material (cement) that fills the space among the aggregate particles and glues them together.

Elements of concrete

The materials are:

Cement: OPC (43 grade) ultra tech cement conforming to IS 8112 was followed. The different laboratory tests were conducted and the results are mentioned in Table 1 and the available percentages of chemical compounds are mentioned in Table 2.

Fly ash: A high quality class F-fly ash from Ennore power plant was used in the ratio of 80:20 in CC. Its physical properties and the available percentages of chemical compounds are mentioned in Table 3 and in Table 4.

Fine aggregate: River sand and recycled fine aggregate are used in the ratio of 80:20 (R. sand: RC. Sand) were taken and its physical properties are mentioned in Table 5.

Coarse aggregate: Particle size distribution and shape of the coarse aggregate is important as it affect the packing and voids content. Specific gravity, water absorption and moister content of all aggregates should be closely checked and must be taken into account in order to make CC of good quality. Maximum size of 20 mm Aggregate was used and its physical properties are mentioned in Table 6.

Water: Ordinary potable water was used.

PROCESSING AND PRODUCTION OF TREATED AGGREGATES

For the production of Treated recycled coarse aggregate and treated recycled fine aggregate, waste concrete in the form of cubes of about 3 Tonnes were obtained from construction site.

Table 1. Properties of cement

S. No.	Test	Result
1	Specific gravity	3.15
2	Water absorption	NA

Table 2. Chemical compounds in cement

Chemical compounds	%
SiO	22.60
Al_2O_3	4.30
Fe_2O_3	2.40
CaO	64.40
MgO	2.10
SO_3	2.30
Na_2O and K_2O	0.60

Table 3. Properties of class F-fly ash

S. No.	Test	Result
1	Specific gravity	2.20
2	Water absorption	NA

Table 4. Chemical compounds in class F-fly ash

Chemical compounds	%
SiO	54.90
Al_2O_3	25.80
Fe_2O_3	6.90
CaO	8.70
MgO	1.80
SO_3	0.60
Na_2O and K_2O	0.60

Table 5. Properties of R. sand

R. sand		
S. No.	Test	Result
1	Specific gravity	2.58
2	Water absorption	1.00

Table 6. Properties of coarse aggregate

Size	Specific gravity	Water absorption
20 mm	3.03	0.37

The concrete cubes are later brought down to smaller fragments by crushing in compression testing machine and later by using hammers manually (Tikalsky, *et al*., 1988; Dhir, *et al*., 1998).

For the production of fine aggregates, the waste concrete material is further broken using hammers to a minimum size of 4.75 mm and down size as shown in (Fig. 1).

The broken aggregates are then sieved through 40 mm, 20 mm, 10 mm and 4.75 mm and aggregates retained in 20 mm and 10 mm sieves are taken as recycled coarse aggregates conforming to the grading of IS383-1970 (Chindaprasirt, *et al*., 2005; Nielsen and Glavind, 2007). The aggregates passing through 10 mm and 4.75 mm are collected as fine aggregates conforming to the specifications of IS383-1970. (Nielsen and Glavind, 2007). As per the requirements of experimental work recycled coarse aggregates and recycled fine aggregates are produced as shown in (Fig. 2).

Treatment of Recycled Concrete Aggregate

The properties of recycled aggregates are lower than natural aggregates as reported by many researchers, it is proposed to treat the recycled aggregates and produce treated recycled aggregates (TRA).

As mentioned in literatures, by using cement and Fly Ash is used in this investigation. The binder mixture of cement and Fly Ash in proportion 1:2 is taken for treatments of 1kg of recycled aggregates. Water used for preparing the binder solution is 210ml/kg of recycled aggregate. The recycled aggregate are soaked in the binder solution so that they are coated with cement Fly Ash solution. The treated coarse aggregates are then left to dry in air and then used as TRCA in the further investigations. Similarly, the recycled fine aggregates are also soaked in the cement-Fly Ash solution till the aggregates are coated with the binder solution as shown in (Fig. 3 and Fig. 4). The treated fine aggregates are then dried in air to develop treated recycled fine aggregate (TRFA). The TRFA and TRCA manufactured as above are used in the further experimental investigations (Tam and Vivian, 2008).

The TRCA and TRFA is produced for the experimental work as shown in (Fig. 5).

PROPERTIES OF MATERIALS

The properties of materials used in this experimental investigation are given in Table 7 below.

EXPERIMENTAL INVESTIGATION

Concrete Mix details

The M20 grade of concrete is designed as per IS method (IS 10262-1982).The mix design is given in Appendix-A at the end of this report. The mix design details are furnished in Table 8 below.

Fig. 1 Crushing of concrete waste into aggregates.

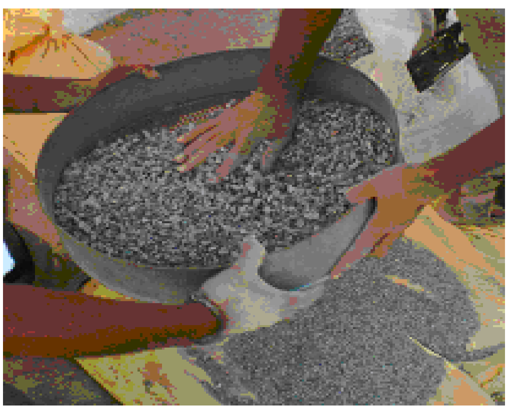

Fig. 2 Sieving of recycled coarse aggregates/fine aggregates.

Fig. 3 Soaking of the recycled coarse aggregates in cement fly ash mixture.

Fig. 4 Soaking of the recycled fine aggregates in cement fly ash mixture.

Fig. 5 View of the treated recycled coarse and fine aggregate.

Table 7. Overall properties of materials

S. No	Property	Experimental results
1.	Specific gravity of cement	3.15
2.	Specific gravity of fine aggregates	2.58
3.	Specific gravity of coarse aggregates	3.03
4.	Specific gravity of recycled concrete coarse aggregate	2.46
5.	Specific gravity of recycled concrete fine aggregate	2.00
6.	Specific gravity of treated recycled coarse aggregate	2.58
7.	Specific gravity of treated recycled fine aggregate	2.18
8.	Water absorption of recycled concrete coarse aggregate	10%
9.	Water absorption of treated recycled concrete coarse aggregate	5%

The above material requirement is meant for natural aggregates and treated recycled aggregates (Gaimster and Kirby, 2008; Jatale, *et al.*, 2013).

Properties of concrete investigated

To investigate on the suitability of 100% replacement of natural aggregates of both CA and FA by treated recycled CA and FA, the compression strength of concrete is assessed. For comparison of the properties, concrete with natural aggregates are manufactured and tested (Swaroop, *et al*., 2013).

PREPARATION OF SAMPLES AND TESTING PROCEDURE

Compression strength of concrete

As per recommendation of IS516-1959, [6] standard dimensions of cubes 150 mm × 150 mm × 150 mm (6 Nos) are cast using natural aggregates and (6 Nos) are cast using treated recycled aggregates. 3 specimens are tested at the end of 14 days and 3 numbers at the end of 28 days as shown in below (Fig. 6).

RESULTS AND DISCUSSION

The compression strength of cubes tested at the end of 14 days and 28 days for natural aggregate concrete and treated recycled aggregate concrete are given in Table 9 and compared in (Fig. 7). The compressive strength of cubes tested at the end of 14 days and 28 days for natural aggregate concrete and treated recycled aggregate concrete are given in Table 9 and compared in (Fig. 7).

From the Table 9 and (Fig. 7) it is found that the compression strength of Treated recycled aggregate concrete with 20% Fly ash decreases by 41.7% at early age i.e., at 14 days and 39.6% at 28 days when compared to natural aggregate concrete.

Fig. 6 Testing of compression strength of concrete cube.

Table 8. Mix design details of M20 concrete

Material	Quantity in Kg/m^3 of concrete
Cement	383
Fine aggregate (Sand)	564
Coarse aggregate (20 mm max size)	1142
Water	192
w/c ratio	0.48
Mix Proportion by weight	1: 1.47: 2.89

Table 9. Compressive strength of concrete

Type of concrete	Compressive Strength (N/mm^2)	
	14 days	28 days
Natural aggregate concrete (NAC)	18.20	28.00
	20.44	28.44
	20.88	28.88
Average	19.84	28.44
Treated recycled aggregate concrete (TRAC) with Fly ash 20%	13.33	16.80
	10.88	16.77
	10.44	17.90
Average	11.55	17.15
% increase/decrease in strength (TRAC-NAC)/NAC	41.7	39.6

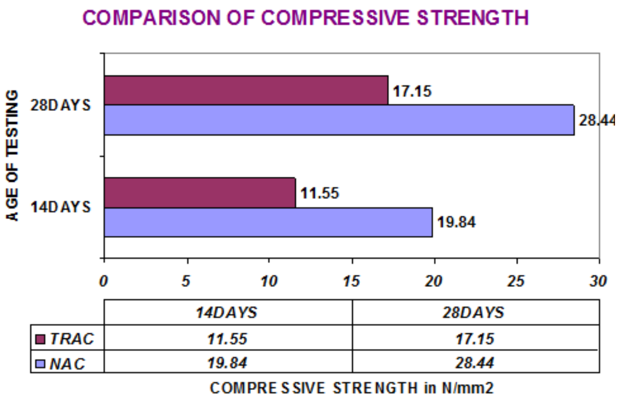

Fig. 7 Comparison of compression strength of NAC and TRAC.

FEASIBILITY OF APPLICATION IN FIELD

A methodology to produce Born Again Concrete from demolished concrete with suitable treatment process has been developed in order to introduce this Born Again Concrete in Structural Elements as trial to outside construction companies with their waste material, men and our technology. As a case study, letters have been sent to construction companies requesting their acceptance. The response from construction companies are very encouraging and it is economically feasible to produce Born again concrete (Concrete Debris) which can be used for variety of engineering applications.

CONCLUSIONS

The suitability of replacement of natural aggregates by 100% treated recycled coarse aggregate and 100% treated recycled fine aggregate in concrete making is assessed experimentally and the conclusions presented.

- The concrete properties of compression strength are found to be higher for the treated aggregate concrete.

- The costs of the developed concrete are lower than the commercially available Ready mix concrete or Natural concrete even at the lowest rate. Even the cost can be brought down if the process is mechanized.
- The feedback from the construction companies is encouraging, which gives a confidence that this technology if implemented can be a valuable contribution to the society.
- Apart from the test results, with regard to economical point of view, recycling process creates additional business opportunities, conserves diminishing resources of urban aggregates thus conserving the environment and also helps in the goal of reducing disposal and disposal rate to some extent.

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