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Study on Effect of Fly Ash on Recycle Coarse Aggregate Concrete

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Abstract

This paper is on recycling and reusing the aggregates obtained from construction and demolition waste to make fresh concrete, and still ensuring that it possesses equal strength and durability as the concrete prepared by using fresh natural aggregate. Using recycled coarse aggregate in concrete helps in environmental protection and it is economical too. Moreover, recycled aggregates are the materials for the future. Fly ash is also a byproduct from various industries; it is also a group of materials which can vary significantly in its composition. In this project, the main aim is to evaluate the physical properties of recycled coarse aggregate and fly ash for M45 grade of concrete combined in this proportion: 1:1.68:2.79. In the tests, the percentages of replaced virgin aggregate were 25%, 30%, 35%, 40% of recycle coarse aggregate and replaced cement was 0%, 10%, 20% of fly ash in concrete. The water cement ratio was taken as 0.4 with super plasticizer of 0.75% by weight of cement for M45 grade of concrete. Slump cone test was conducted to determine the workability property of fresh concrete and compressive, flexural and split tensile strength was conducted to evaluate the hardened properties of concrete. Modulus of elasticity was also presented for different mixes. The results show that recycled aggregate can be used up to 30% with 10% of fly ash for making concrete.

Keywords: *Recycled coarse aggregate (RCA), Fly ash, Slump test, Compressive strength test, Flexural strength test, Split tensile strength test, Modulus of elasticity.*

INTRODUCTION

Concrete is the major material in construction that can be used in all types of civil engineering works across the world. It is the basic material used for building high and low rise buildings, defense installations, environmental protection measures, and residential

constructions. The aggregates are traditionally available at suitable prices conforming to varying qualities. The use of aggregate from the natural resource and the knowledge of wholesale extraction are valid even for international level.

Fly ash is a group of materials that can vary in composition. It is obtained from burning coal that can be collected on an electrostatic precipitator. Fly ash can be added to structural concrete at 15-35% by weight of cement and it is added to mass concrete up to 70% to be used in dams, roller compacted concrete pavement and parking areas. Fly ash improves the performance of both fresh and hardened state in concrete.

MATERIAL

The materials used in the experimental investigation are available commercially and include cement, fine aggregates, coarse aggregate, recycled coarse aggregate, fly ash and super plasticizer (conplast 430). The specifications and properties of these materials are as under:

Cement: Ordinary Portland cement (OPC 43G) was used in the study.

Table 1: Properties of Ordinary Portland Cement (OPC 43 grade)

Sl. No	Properties	Result
1	Specific gravity	3.05
2	Normal consistency	31%
3	Initial setting time	65 min
4	Final setting time of cement	590 min

Fine Aggregate: Locally available river sand is used as fine aggregate.

Table 2: Properties of Fine Aggregate (FA)

Sl. No	Properties	Result
1	Specific gravity	2.65
2	Fineness modulus	conforming zone II requirement as per IS 383-1970
3	Water absorption	1%

Natural Coarse Aggregate (NCA): Gravels used as NCA were locally procured. Their average particle size was 20 mm.

Table 3: Properties of NCA

Sl. No	Properties	Result
1	Specific gravity	2.7
2	Water absorption	0.48%
3	Impact test	21.79%
4	Crushing test	29.35%

Fly ash (FA): FA is one of the residues generated in combustion; it comprises of fine particles that rise with the flue gases. Ash that does not rise is termed bottom ash.

Table 4: Properties of FA

Sl. No	Properties	Result
1	Specific gravity	2.4

Recycled coarse aggregate (RCA): RCAs used were crushed to 20 mm average particle size.

Fig 1: Recycled Coarse Aggregate

Fig 2: Fly Ash

Table 5: Properties of RCA

Sl. No	Properties	Result
1	Specific gravity	2.45%
2	Water absorption	1.43%
3	Impact test	27.26%
4	Crushing test	34.03%

AIMS AND OBJECTIVES OF THE STUDY

Concrete is the basic material used for all construction works. By keeping this in view, some supplementary materials are used for concrete. Based on literature review, the following objectives can been investigated:

- To determine the basic properties of materials used as per IS specification.
- To carry out different tests on fly ash and recycled coarse aggregate to verify the suitability and comparing the results with natural coarse aggregate.
- To carry out different tests on concrete made of fly ash, recycled coarse aggregate, natural coarse aggregate such as slump cone, compressive strength, flexural strength, split tensile strength and modulus of elasticity.
- To find the optimum dosage of recycled coarse aggregate and fly ash in concrete based on strength parameter.

METHODOLOGY

The objectives mentioned above were accomplished in the following ways:

- Mix for M45 was designed with locally available materials.
- The slump test was conducted to find the workability of concrete before casting cubes.
- The percentages of replaced virgin aggregate were 25%, 30%, 35%, 40% of recycle coarse aggregate and cement was replaced with 0%, 10% and 20% fly ash.
- Compressive strength is tested for 7, 28 and 56 days. Flexural strength, Split tensile strength and modulus of elasticity is tested for 28 days.

RESULTS AND DISCUSSION

The main objective of this study was to investigate various mix proportions with fly ash and recycled coarse aggregate. Table 6 shows the results of various mix proportions and the graphs are depicted from fig 1 to fig 5. The results obtained are discussed below.

Table 6: Results of slump, density and compressive strength

Mix		Slump Value (mm)	Density (kg/m^3)	Compressive strength (N/mm^2)			
FA%	RCA%			7 days	28 days	56 days	
0	0	100	2548	43.76	49.70	55.46	
10	0	103	2540	39.84	52.87	63.53	
20	0	110	2538	38.66	50.06	58.48	
0	25	80	2527	31.05	38.11	49.09	
0	30	65	2503	33.01	42.38	50.32	
0	35	50	2493	24.39	36.50	43.44	
0	40	30	2488	22.78	30.78	38.65	
10	25	85	2546	33.15	50.15	56.64	
10	30	70	2538	37.44	53.48	58.39	
10	35	55	2535	35.45	48.49	53.56	
10	40	40	2530	29.30	40.41	44.24	
20	25	95	2522	30.75	48.4	51.56	
20	30	75	2506	35.27	50.9	54.82	
20	35	60	2480	30.3	42.69	50.5	
20	40	45	2445	29.7	38.89	40.46	

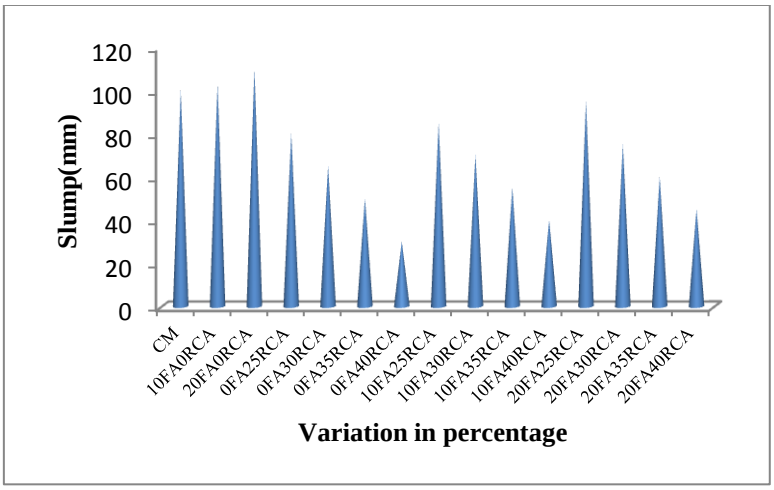

Fig 1: Slump Value vs. Variation in Percentage

From Fig 1 it is observed that the workability is increased when fly ash is added due to finer particles present. Later an increase of RCA content decreased workability decrease that was caused by high water absorption of RCA.

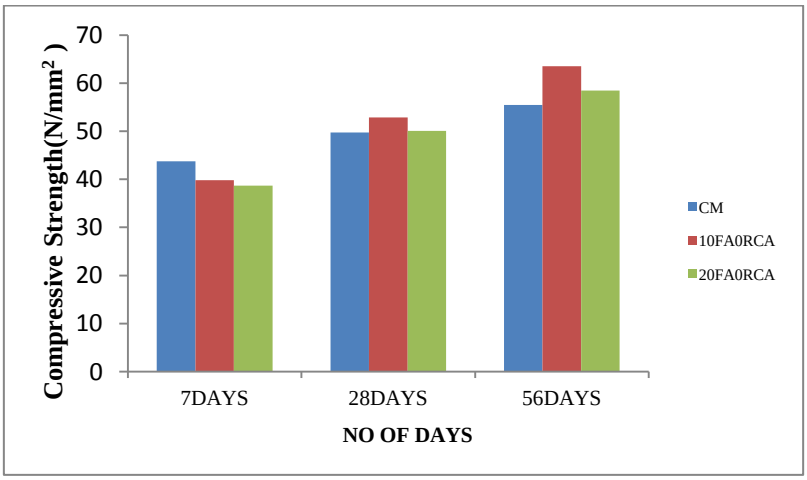

Fig 2: Compressive strength vs. % Replacement Cement by FA

From Fig 2 it is observed that when fly ash is added the strength goes on increasing, and this ensures that addition of fly ash increases the formation of C-S-H gel, which increases the strength of concrete.

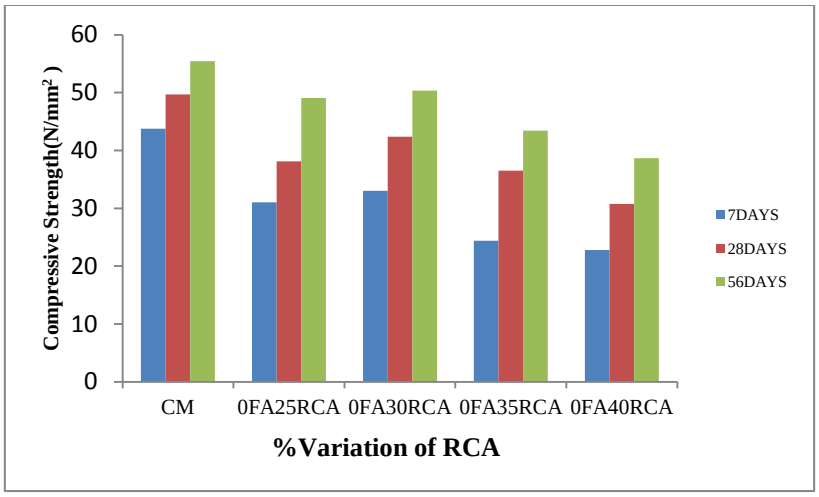

Fig 3: Compressive strength vs. Replacement of NA by RCA For 0 % FA

From Fig 3 it is observed that compressive strength increases when RCA is added up to 30% and suddenly the strength decreases when RCA is in greater percentage. This may be due to the bonding between the old mortars on the surface of RCA.

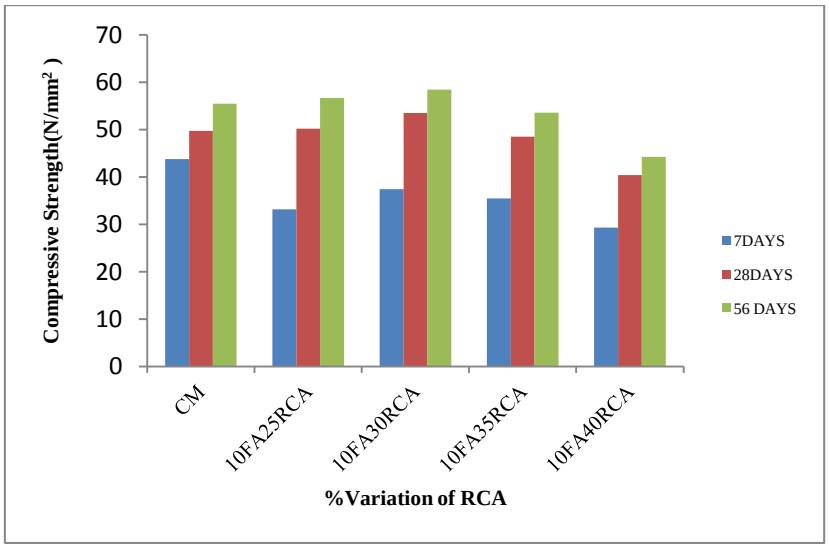

Fig 4: Compressive strength vs. Replacement of NA by RCA for 10 % FA

From Fig 4 it is observed that when 10 % of fly ash is added to NA with RCA, the strength goes on to increase up to 30% of RCA but decreases suddenly.

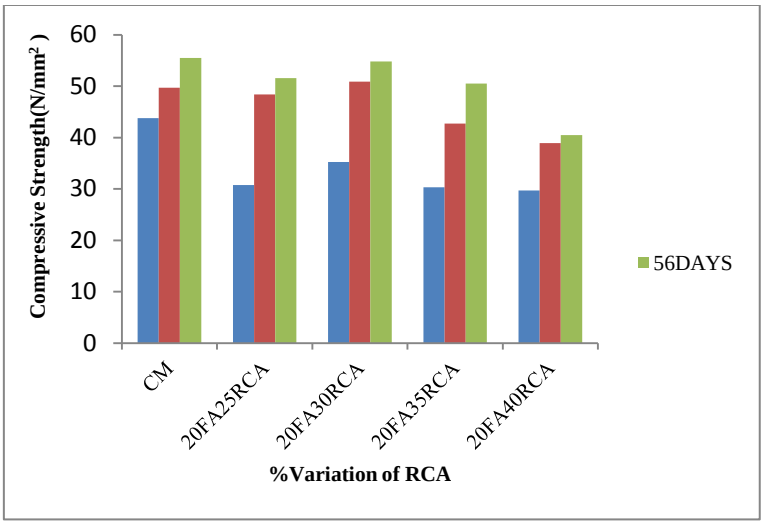

Fig 5: Compressive strength vs. Replacement of NA by RCA for 20 % FA

Fig 5 shows that when 20% of fly ash is added to NA with RCA, the strength goes on to increase up to 30% of RCA but decreases suddenly. This may be due to addition of fly ash to the concrete which increases the strength, but further addition of RCA decreases the strength of concrete due to the adhered mortar present in RCA that absorbs the water when compared to control mix.

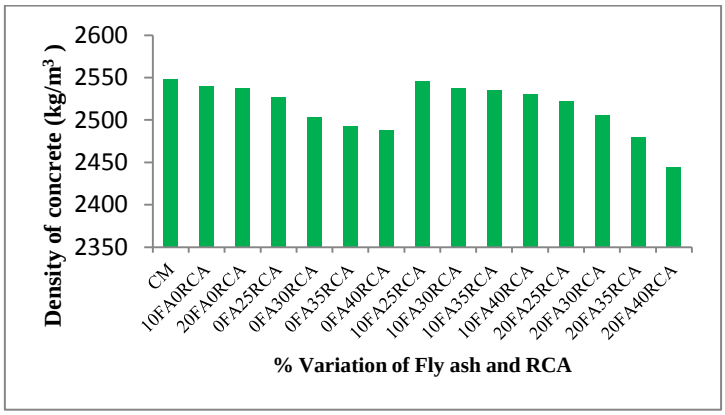

Fig 6: Density of Concrete vs. Variation in Percentage

Fig. 6 graphically represent the density of concrete with various percentages of fly ash and RCA. The density of concrete will be low due to the finer particles present in fly ash and old mortar in recycled aggregate.

Table 7: Results of flexural strength, split tensile strength and modulus of elasticity

Types of Mixes	Flexural Strength for 28 days(N/mm^2)	Split tensile strength for 28 days(N/mm^2)	Modulus of Elasticity for 28 days(N/mm^2)
CM	4.4	3.5	29616
10FA0RCA	4.8	3.35	29869
20FA0RCA	4.64	3.2	29593
0FA25RCA	3.8	3.1	24490
0FA30RCA	3.6	2.84	25470
0FA35RCA	3.4	2.69	23154
0FA40RCA	3.35	2.4	21956
10FA25RCA	4.28	3.52	32180
10FA30RCA	4.55	3.59	34220
10FA35RCA	4.46	3.12	31470
10FA40RCA	4	3.01	30600
20FA25RCA	4.1	3.4	31770
20FA30RCA	4.48	3.54	33240
20FA35RCA	4.2	3.06	30580
20FA40RCA	3.9	2.9	29700

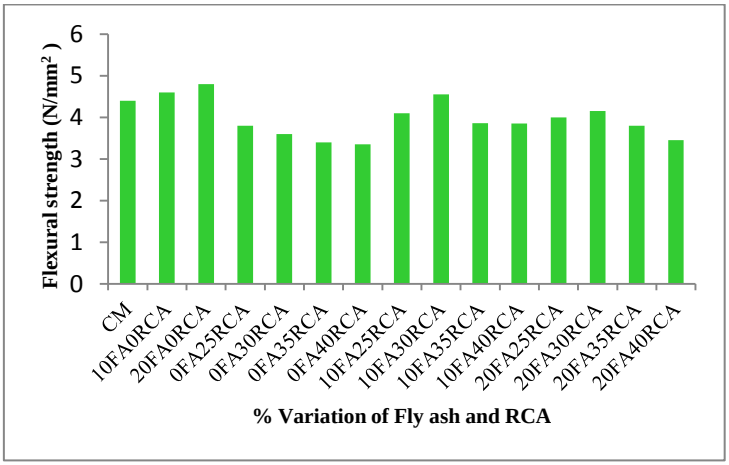

Fig 6: Flexural strength vs. Replacement of NA by RCA For 0 % FA

Fig 6 graphically represents the flexural strength of concrete with addition of fly ash and RCA at 28 days of curing. The strength increased was due to the addition of fly ash. By addition of RCA the strength decreased due to mortar present in it.

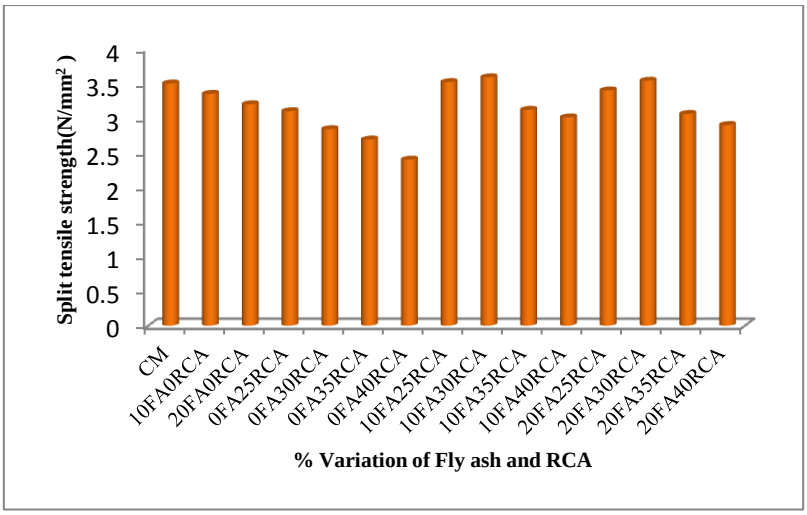

Fig 7: Split tensile vs. Replacement of NA by RCA For 0 % FA

Fig 7 graphically represents the split tensile strength of concrete with addition of fly ash and RCA at 28 days of curing. The strength decreased due to addition of fly ash containing finer particles and by addition of RCA, the strength decreased because of the presence of mortar in it.

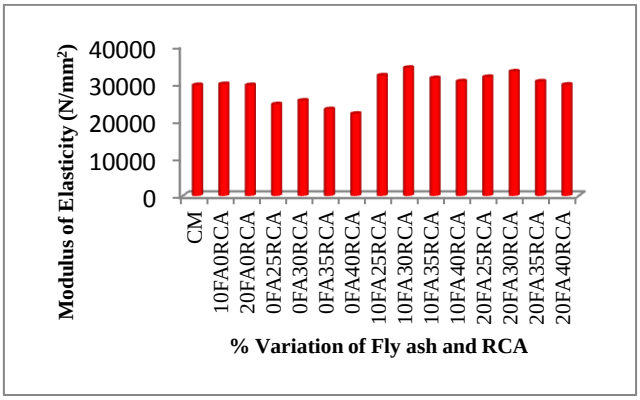

Fig 8: Modulus of elasticity vs. Replacement of NA by RCA For 0 % FA

From Fig 8 it is observed that when percentage of fly ash is added to NA with RCA, the strength goes on to increase by up to 30% of RCA and suddenly decreases. This may be due to fine particles in fly ash and later when RCA is added, it absorbs water due to mortar present in it.

CONCLUSION

By the observation of present study, which was carried out with fly ash and RCA, we arrive at the following conclusion:

- The specific gravity of RCA is less than the conventional coarse aggregate concrete.
- The water absorption of RCA is higher than the natural concrete and this may be due to the adhered mortar present in RCA.
- Workability of fresh concrete was increased by the addition of fly ash to the concrete.
- The compressive strength of 58.39 N/mm2 for 56 days with addition of 10% of fly ash and 30% of RCA.
- Split tensile and Flexural strength was found to be maximum at 10% of fly ash and 30% of RCA with 3.59 N/mm2 and 4.55 N/mm2 respectively.
- Modulus of elasticity of concrete by the addition of RCA in different proportions resulted in decrease of the strength whereas by further addition of fly ash with RCA, the strength decreased at 10% of fly ash with 30% of RCA compared to control mix.

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