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Study On Flexural Behaviour Of Reinforced Concrete Beam By Incorporating Cement Bonded Fly Ash Aggregate To Natural Aggregates

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The production of concrete requires huge quantities of natural sources, especially, lime stone, coarse aggregate, and river sand. Fine and coarse aggregates constitute about 75 % of its total volume of concrete of which coarse aggregates alone constitute about 30 to 40%. In this context, it is of immense help to the environment that the industrial waste products are used in place of virgin materials for the production of aggregate.

In the present study manufacturing pro-cess of cement bonded fly ash aggregates using an ordinary concrete mixer and its properties are studied. Three different proportions of fly ash and or- dinary Portland cement were selected 95:05(FAA1),90:10(FAA2) and 85:15(FAA3) (fly ash: cement) to manufacture the fly ash aggregates. The partial replacement of cement bonded fly ash aggregates by conventional aggregates in a concrete mix with replacement percentage of 25%,50%,75%and 100%. The Properties of fly ash aggregate concrete were observed through Compressive strength, Flexural Strength, crack width and Rapid Chloride Penetration test.

It is found from the experimental results that, the compressive strength of a concrete mix of 100 % replacement of natural aggregate by Fly ash aggregate (85:15) shows acceptable in the production of concrete and maximum compressive strength for fly ash aggregate (85:15) with 75% replacement of natural aggregate. The flexural capacity of the of RC beam with fly ash ag- gregate increases by increasing the diameter of reinforcement and decrease in the replacement of fly ash aggregate beam and the crack width de-creases as an increase in the replacement of the fly ash aggregate up to 50% in concrete. The durability property of concrete blended with fly ash aggregate shows similar results like conventional concrete. From the RCPT results in its shows that Fly ash aggregate concrete and conventional concrete both are in the moderate zone only.

Keywords: Fly Ash, Fly Ash aggregate, Pelletization, Mechanical properties, Flexural behavior, Crack width

1. INTRODUCTION

Expensive and scarcity of natural aggregate which is one of the constituent materials used in the production of conventional concrete was reported in India. To overcome the stress and demand for natural aggregate, researchers and practitioners in the construction industries have identified some alternative to natural aggregates, namely steel slag aggregate, crushed bricks, copper slag aggregate. Flyash aggregate etc. [1]. fly ash aggregates can be manufactured in the different proportion of fly ash, cement, the aggregate which is manufactured is lightweight aggregate. When this aggregate used in concrete that means, indirectly in the construction industry has so much application [3]. Due to the use of this type of aggregate in the concrete production of lightweight concrete can be done. Design and construction by this type of concrete are economical because due to nature of light weight reduces the self-weight. It leads to a decrease in self-weight of the structure so that there is no need for any other additional structures [5]. The aggregates so prepared are known as Fly ash aggregates, the method of formation is known as pelletization.

CEMENT FLY ASH WATER FA AGGREGATE

Figure: 1 Pelletization Technique

2. EXPERIMENTAL PROGRAM

The concrete mix was designed as per IS 10262-2004 and Fly ash aggregate is produced by the ordinary concrete mixer.

2.1 Materials used

2.1.1 Cement

In the present experimental studies, Birla super cement of 53 grade confirming to IS 8112 1989 was used and the cement sample was tested as per IS-4031-1988 and IS 269-1976.

2.1.2 Fine Aggregate

In the present work, sand (local crushed sand) was used as fine aggregate with a fineness modulus of 2.39 and specific gravity of 2.679. Fine aggregate is classified as zone III as per IS: 2386 (I, III).

2.1.3 Coarse aggregate

For the experimental work, locally available crushed stone aggregates of size 20mm to 4.75mm were utilized the different tests were carried out on the aggregates as per IS 2386- 1988 part III.

2.1.4 Fly ash

Fly ash of class F grade was from Raichur Thermal power plant (RTPS) was used in present work The power plant is situated at 16°21′18″N77°20′31″E Coordinates; It is 18km away from Raichur district of Karnataka and specific gravity of fly ash is 2.0 Potable water was utilized for the project work and which is free from chloride.

2.1.5 Chemical admixtures
In order to improve the workability of fresh concrete, naphthalene based super Plasticizer (Glenium 720) was used

2.2 Fly ash aggregate

2.2.1 Preparation of fly ash aggregate

- Fly ash and Ordinary Portland cement were selected indifferent proportions like [Fly ash: cement] 95:5, 90:10, 85:15.
- These proportions are thoroughly dry mixed in Concrete Mixer.
- After dry mix in a mixer start sprinkling the water until the formation of fly ash aggregates.
- The contents were thoroughly mixed in concrete mixer until the formation of fly ash aggregate. The method of formation is called palletization.
- Once the aggregate formed from the mixer allowed to dry for a day and kept for water curing at 7 days.

Figure 2: Collection of Fly Ash Aggregates from Mixer

2.2.2 Segregation of fly ash aggregates
After curing, fly ash aggregates were segregated into fine and coarse aggregates based on the size of the pellets shown in Figure 3. The aggregates having a size less than 4.75mm were sieved as fine aggregates and size more than 4.75 mm have sieved as coarse aggregates.

Figure 3: Collection of Fly Ash Aggregates from Mixer

2.2.3 Sieve analysis of Fly Ash aggregates

The Fineness Modulus of the Fly ash aggregate almost similar to the Fineness modulus of the Coarse aggregate, the gradation curve **S** shapes almost similar to Normal Aggregate gradation curve as shown in Figure 4.

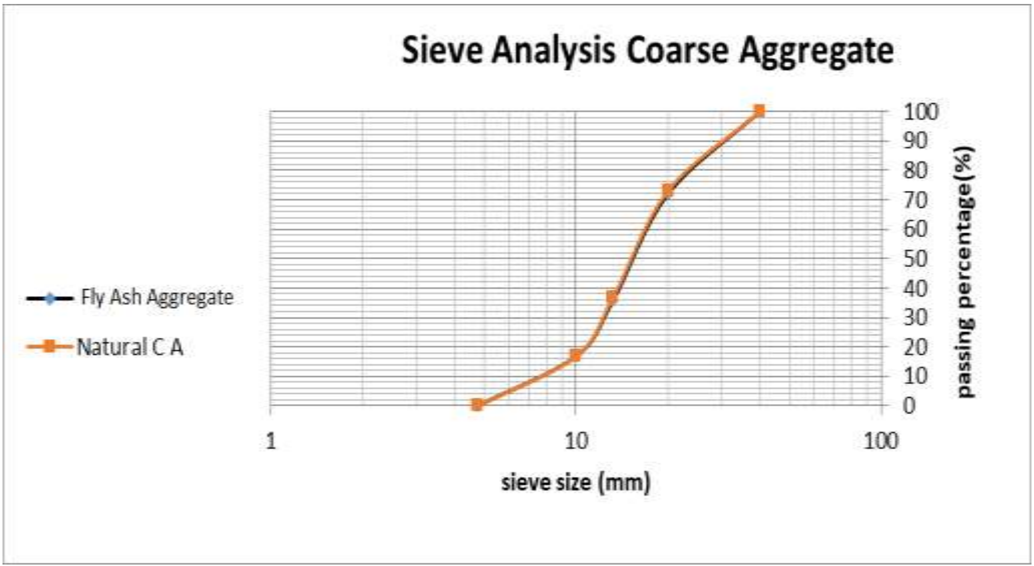

Figure 4: Grain Size Distribution Curve

2.2.4 Characterization of fly ash aggregate

The aggregates characterization are done by conducting the following tests as per IS 2386 Part III: 1990 and IS 2386 Part IV: 1990 and the properties of the crushed unprocessed ag- gregates and Fly ash aggregate were found. The properties of Coarse Aggregate along with the properties of Fly ash aggregates are presented in Table1

Table 1: Specification of aggregate cured by water (7 days)

Ratios (Fly ash: cement)				
Tests	95:05	90:10	85:15	Conventional
Specific gravity	1.5	1.51	1.68	2.73
Absorption (%)	15.7	10.5	3.5	0
Bulk density(kg/m^3)	915	940.7	964.98	1600
Angularity	10.9	12.2	10.59	9
Impact value (%)	43.62	44.368	25.36	27
Crushing value (%)	41.77	42.3	26.3	25
Fineness modulus	6.2	6.22	6.82	7

2.3 RCC Beam Specification

2.3.1 The flexural strength characteristics of RC fly ash aggregate concrete beam is carried for following details of the specification as shown in table 2

Table 2: Structural design details of beams

Span length	1500mm
Effective length	1350mm
Width of beam	100mm
Overall depth of the beam	150mm
Effective depth of the beam	130mm
Anchor bars	2 bars of 8mm
Shear reinforcement	2 legged 8 mm @100 mmc/c
Clear cover to reinforcement	20mm

3. MECHANICAL PROPERTY OF FLY ASH AGGREGATE CONCRETE

3.1 compressive strength of fly ash aggregate concrete

Compressive strength for M25 grade concrete with fly ash aggregate (85:15) replacement of

50 % showed the good results than Conventional Concrete with Natural Aggregate.

Table 3: Compressive strength of fly ash aggregate concrete

Ratios (Cement : Fly ash)	Compressive strength (MPa)							
	25% Replacement		50% Replacement		75% Replacement		100 % Replacement	
	7 days	28 days	7 days	28 days	7 days	28 days	7 days	28 days
95 : 5	21.73	25.32	13.96	22.15	12.4	18.9	10	15.56
90 : 10	24.1	29.5	18.56	26.40	17.2	21.5	14	19.54
85 : 15	33	**40.8**	26.31	**31.30**	21.5	23.5	19.53	**25.60**
Conventional M25 Concrete	21.23	37.32	21.23	37.32	21.23	37.32	21.23	37.32

3.2 flexural strength of fly ash aggregate concrete

Based on the maximum compressive strength of fly ash aggregate concrete the flexural strength characteristics of RC fly ash aggregate beam is carried out for a beam specimen by varying the diameter of reinforcement and results are tabulated in table 4

Table 4: Flexural strength of fly ash aggregate concrete

Beam Series	Pcr (kN)	Psl	Pu (KN) (kN)	CR (mm)	SL	U (mm) (mm)
CB-8mm	12	26	42	2.22	4.09	12.13
FB-25-8mm	12	23	42	1.93	4.47	13.73
FB-50-8mm	12	22	42	1.83	4.45	12.4
CB-10mm	14	28	52	1.78	4.09	10.05
FB-25-10mm	16	30	50	1.13	3.14	9.01
FB-50-10mm	18	32	48	2.03	4.52	9.12

CB-Control beam , FB-Fly ash aggregate beam, Pcr-First visible cracking load in (kN), Psl-Service load in (kN), Pu-Ultimate failure load (kN),CR- midspan deflection @ crack load in (mm), SL-Midspan deflection @ service load in (mm), U- Midspan deflection @ ultimate failure load in (mm)

3.3 Deflection and crack width

Based on the maximum compressive strength of fly ash aggregate concrete the deflection and crack width characteristics of RC fly ash aggregate beam is carried out for a beam specimen by varying the diameter of reinforcement and results are tabulated in table 5.

Table 5: Deflection and crack width of fly ash aggregate concrete

Beam Speci-men	**CB**	**FA25**	**FA50**	**CB1**	**FA25**	**FB50**	**CB**	**FA25**	**FA50**	**CB1**	**FA25**	**FB50**
Diameter rein-force-ment(mm)	8	8	8	10	10	10	8	8	8	10	10	10
Load in (KN)			Deflection (mm)				Crack width in concrete (mm)					
0	0	0	0	0	0	0		00	0	0	0	0
2	0.57	0.19	0.16	0.26	0.25	0.29		00	0	0	0	0
4	0.72	0.38	0.36	0.27	0.31	0.36	0	0	0	0	0	0
6	0.8	0.62	0.44	0.36	0.37	0.47	0	0	0	0	0	0
8	1.15	0.85	0.67	0.52	0.42	0.64	0	0	0	0	0	0
10	1.46	1.31	1.11	0.86	0.78	0.87	0	0	0	0	0	0
12	2.22	1.93	1.83	1.11	0.95	1.07	0.02	0.02	0.02	0	0	0
14	2.64	2.39	2.32	1.78	0.98	1.42	0.06	0.04	0.04	0.02	0	0
16	3.06	2.6	2.85	1.99	1.13	1.78	0.08	0.08	0.06	0.04	0.02	0
18	3.36	3.21	3.34	2.75	1.36	2.03	0.1	0.14	0.1	0.06	0.04	0.02
20	3.55	3.99	3.99	2.75	1.69	2.31	0.12	0.16	0.12	0.08	0.06	0.04
22	3.74	4.18	4.45	3.14	2.19	2.6	0.16	0.18	0.18	0.1	0.08	0.06
24	3.9	4.77	5.02	3.51	2.46	2.87	0.18	0.2	0.19	0.12	0.1	0.08
26	4.09	5.26	5.46	3.89	2.85	3.15	0.2	0.24	0.22	0.14	0.12	0.1
28	4.92	5.91	5.81	4.09	2.97	3.46	0.24	0.28	0.28	0.2	0.16	0.14
30	5.32	6.53	6.64	4.42	3.14	3.89	0.28	0.32	0.54	0.22	0.2	0.16
32	5.66	7.28	7.31	4.76	3.67	4.52	0.3	0.56	0.6	0.26	0.22	0.2
34	6.26	7.79	8.15	5.11	3.94	4.69	0.58	0.62	0.68	0.3	0.24	0.3
36	7.18	8.65	9.9	5.43	4.06	5.02	0.62	0.66	0.9	0.4	0.28	0.32
38	8.25	9.69	10.2	6.08	4.56	5.31	0.7	0.74	1.1	0.46	0.3	0.34
40	11.26	11.24	11.01	6.39	4.89	5.61	0.82	0.92	1.2	0.48	0.78	0.76
42	12.13	13.73	12.4	6.94	5.19	5.93	1.2	1.3	1.4	0.68	0.8	0.82
44	-	-	-	7.36	6.27	6.31	-	-	-	0.76	0.96	0.96
46	-	-	-	7.96	7.2	6.75	-	-	-	0.84	1	1.2
48	-	-	-	8.49	8.14	9.12	-	-	-	0.96	1.2	1.5
50	-	-	-	8.48	9.01	-	-	-	-	1.02	1.3	-
52	-	-	-	10.05	-	-	-	-	-	1.4	-	-

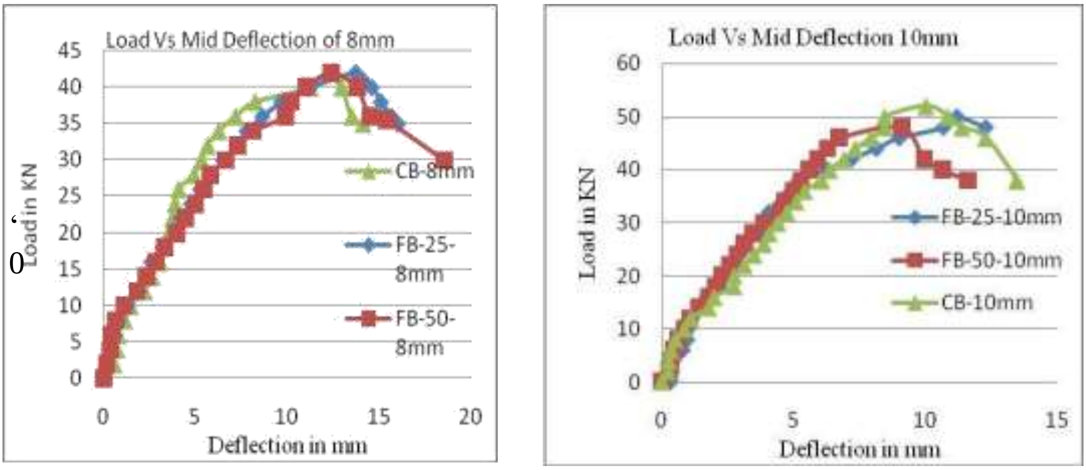

Figure 5: Load Deflection Curve

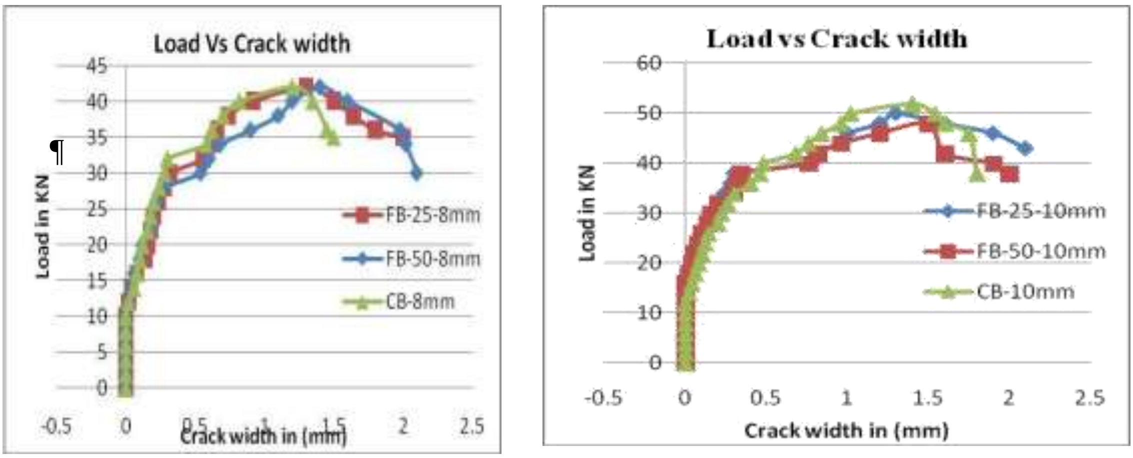

Figure 6: Cracking characteristics of different beam series

4. DURABILITY OF FLY ASH AGGREGATE CONCRETE

4.1 Rapid Chloride Penetration Tests

The concrete specimen of diameter 100mm and length 50 mm prepared then soak the specimen in a water for curing up to 28 days. After 28 days the specimen is removed from the curing and pe- riphery of the specimen is coated by using epoxy and allow it for surface drying. Then the speci- men is immersed in the water up to 48 hours. preparing the solutions 3%Nacl and 0.3NaoH. And reading is taken for every 30 minutes and experiment is conducted for 6 hours

Figure 7: RCPT Test Apparatus

Table 6: Rapid chloride penetration tests value

Mix Proportion (FA:Cement)	Proportion Of Concrete	Charge In Coulombs	Chloride Penetration
(85:15)	CC	2376	Moderate
	25% FA	2547	Moderate
	50% FA	2654	Moderate

5. CONCLUSIONS

5.1 Properties of Fly Ash Aggregates

- Fly ash and Cement in the range 95:05, 90:10 and 85:15 respectively were dry mixed and fed in a concrete mixer with a known amount of water and required numbers of ro- tations were given until the formation of Fly ash aggregates. Formed FA aggregates af- ter curing were graded.
- The specific gravity of the manufactured FA aggregates is in the range of 1.5 to 1.68as compared to conventional aggregate specific gravity is 2.73. It clearly indicates that the manufactured FA aggregates are lightweight material.
- The bulk density of fly ash aggregates is 910 to 1100 kg/m3, the fly ash aggregates are low density compared to the natural aggregates.
- Three different proportions of fly ash aggregates in that 85:15aggregates, the crushing and impact value is more compared to the other two proportions.

5.2 Mechanical Properties of Fly Ash Aggregate Concrete

- The compressive strength of M25 grade fly ash aggregate concrete with 25% replacement of 85:15 fly ash aggregate 40.8 MPa is more comparable to the other proportion and conventional concrete of 37.32 MPa.

- The flexural capacity of the of RC beam with fly ash aggregate increases by increasing the diameter of reinforcement and decrease in the replacement of fly ash aggregate beam and the crack width decreases as an increase in the replacement of the fly ash aggregate up to 50% in concrete

- **Load-deflection characteristics**

The load-deflection characteristics for RC beams with and without fly ash aggregates are found to be nearly identical. The RC beams with **50%** fly ash aggregates showed a slightly higher stiffness up to service load. Beyond service load stage the load-deflection characteris- tics showed a distinct change with the onset of profuse cracking.

- **Crack widths**

Beams incorporating fly ash aggregate exhibited lower crack width at all stages. RC beams with higher diameter reinforcement exhibited higher crack width compared to lower diameter reinforcement due to the reduced surface area of reinforcement. The crack patterns and failure modes observed for all beams were found to be similar. The total numbers of the flexural cracks developed were almost the same for a particular mix and percentage of reinforcement used in the beams.

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