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Experimental Investigation of Fiber Reinforced Concrete Using Flyash

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ABSTRACT

Flyash is a waste product which is generated in thermal power stations. The quantity of fly ash produced from thermal power plants in India is approximately 270 million tons each year, and its percentage utilization is less than 15%. During the last few years, some cement companies have started using fly ash in manufacturing cement, known as ' Portland Pozzolana cement', but the overall percentage utilization remains very low, and most of the fly ash is dumped at landfills. Fine aggregate is natural resource in nature and to meet the demand of concrete in construction we are exploiting it gradually. Here concrete is made by using flyash as replacement to sand. In this way can save the natural resource by reducing its usage by using alternative product.

Concrete containing fly ash as partial to complete replacement of fine aggregate will improve its strength on long-term basis. In this investigation fly ash is used as sand replacement material. The material mix of proportion 1:1.58:3.2 Each category comprises of various percentages of sand replacement material in increasing order i.e. 0%, 20%,40%,80% and 100%. In addition to this slit-sheet steel fiber of 1% and 2% is incorporated for concrete works. The workability is maintained constant range for all mixes. Strength characteristics such as compressive strength, split tensile strength and flexural strength of concrete mixes are found out for 7, 14 and 28 days curing period and results are analyzed.

Keywords : Fly-Ash, Power Stations, Portland Pozzolana Cement, Fine Aggregates, Slit-sheet steel, Compression, Tension, Flexure

I. INTRODUCTION

The demand for building materials like cement, sand and coarse aggregate is increasing in the country due to increase in growth of population, economy and living standards of the people. Cement production in the country is assessed to be 347 metric tonnes per annum. Cement production grew by 5% every year. Cement concrete is the most chosen material of the construction for its wide variety of skills, ease in production and use. There are three aspects in the use of concrete. The first one is the durability aspect. The second aspect is the economy in construction by improved design and cost reduction in cost of materials. The third aspect is energy preservation and environment protection. Can satisfy these three aspects by using the fly ash in concrete.

II. METHODS AND MATERIAL

Table 1. Chemical Composition and Classification

Component	Bituminous	Subbituminous	Lignite
SiO_2 (%)	20-60	40-60	15-45
Al_2O_3 (%)	5-35	20-30	20-25
Fe_2O_3 (%)	10-40	4-10	4-15
CaO (%)	1-12	5-30	15-40
LOI (%)	0-15	0-3	0-5

1.1 Class F fly ash

The burning of harder, older anthracite and bituminous coal typically produces Class F fly ash. This fly ash is pozzolanic in nature, and contains less than 20% lime (CaO). Possessing pozzolanic properties, the glassy silica and alumina of Class F fly ash requires a cementing agent, such as Portland cement, quicklime, or hydrated lime, with the presence of water in order to react and produce cementitious compounds. Alternatively, the addition of a chemical activator such as sodium silicate (water glass) to a Class F ash can lead to the formation of a geopolymer.

Figure 1. Class-F fly-ash

1.2 Class C fly ash

Fly ash produced from the burning of younger lignite or sub-bituminous coal, in addition to having pozzolanic properties, also has some self-cementing properties. In the presence of water, Class C fly ash will harden and gain strength over time. Class C fly ash generally contains more than 20% lime (CaO). Unlike Class F, self-cementing Class C fly ash does not require an activator. Alkali and sulfate (SO_4) contents are generally higher in Class C fly ashes.

US manufacturer has announced a fly ash brick containing up to 50% Class C fly ash. Testing shows the bricks meet or exceed the performance standards listed in ASTM C 216 for conventional clay brick; it is also within the allowable shrinkage limits for concrete brick in ASTM C 55, Standard Specification for Concrete Building Brick. It is estimated that the production method used in fly ash bricks will reduce the embodied energy of masonry construction by up to 90%. Bricks and pavers were expected to be available in commercial quantities.

1.3 Cement

Pozzolana Portland Pozzolana cements conforming to IS 8112: 1989 was used.

1.4 Fine Aggregate

Locally available river sand passing through 4.75 mm I.S .Sieve is used. The specific gravity of the sand is found to be 2.62.

1.5 Natural Coarse Aggregate.

Crushed granite aggregate available from local sources has been used. To obtain a reasonably good grading, 60% of the aggregate passing through 20 mm I.S. sieve and retained on 12.5mm I.S. Sieve and 40% of the aggregate passing through 12.5mm I.S. Sieve and retained on 10 mm I.S. Sieve is used in preparation of NAC and LSA.

Figure 2. Natural Coarse Aggregates

2. Test Set up and testing

2.1 Cube Compressive Strength Test

The test set up for conducting cube compressive strength test is depicted in Figure: 4.3. Compression test on cubes is conducted with 2000kN capacity compression testing machine. The machine has a least count of 1kN. The cube was placed in the compression-testing machine and the load on the cube is applied at a constant rate till to failure of the specimen and the corresponding load is noted as ultimate load. Then cube compressive strength of the concrete mix is then computed by using stand formula.

2.2 Split Tensile Strength

The cylinder is placed on the bottom compression plate of the testing machine and is aligned such that the center lines marked on the ends of the specimen are vertical. Then the top compression plate is brought into contact at the top of the cylinder. The load is applied at uniform rate, until the cylinder fails and same load is taken in to account as ultimate load. From this load, the splitting tensile strength is calculated for each specimen by stand formula.

2.3 Flexural Strength Test

The loading arrangement to test the beam specimens for flexure is shown in Figure: 4.9. The test is conducted on a loading frame. The beam element is simply supported on two rollers of 4.5 cm diameter over a span of 450 mm. The element is checked for its alignment longitudinally and adjusted if necessary. Required packing is provided using rubber material. Care was taken to ensure that the two loading points were at the same level. The loading was applied on the specimen through hydraulic jacks and was measured using a 15 tones pre-calibrated proving ring. The load is transmitted to the beam element through the I-section and two 16mm diameter rods spaced at a distance of 150mm. For each increment of loading, the deflections at the center of span are recorded using dial gauges. Continuous observations were made and the cracks were identified with the help of magnifying glass. Well before the ultimate stage, the deflect meters were removed and the process of load application was continued till to continued total failure and at this stage the load is recorded as ultimate load.

III. RESULTS AND DISCUSSION

Table 2 : Workability of Concrete.

S.No	Nomenclature	Compaction Factor(CF) 0%	Compaction Factor(CF) 1%	Compaction Factor(CF) 2%
1.	NC	0.968	0.868	0.768
2.	FC 20	0.982	0.891	0.792
3.	FC 40	0.992	0.932	0.832
4.	FC 80	0.974	0.924	0.874
5.	FC 100	0.991	0.941	0.921

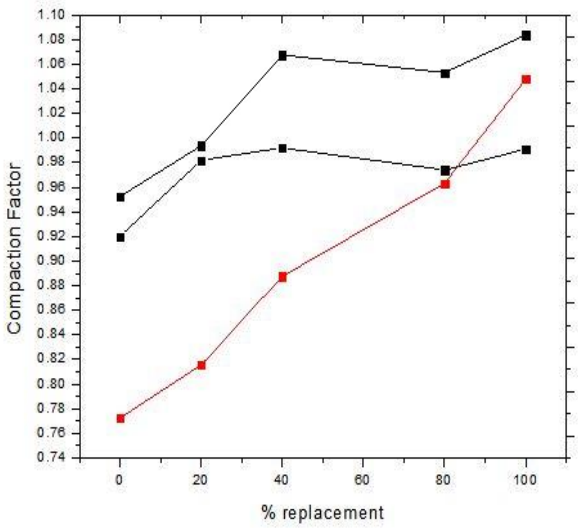

Figure 3. Compaction Factor vs % replacement of flyash.

Table 3. Compressive Strength of fly ash concrete for 28 days with 0% fiber

S. No	Nomenclature	Ultimate Load(kN)	Ultimate Stress(N/mm2)	increase in compressive strength	Decrease in compressive strength
1.	NC	801.30	35.61		
2.	FC 20	1052.81	46.79	11.19	
3.	FC 40	1065.90	47.37	11.76	
4.	FC 80	803.17	35.69	0.09	
5.	FC 100	704.99	31.33		4.28

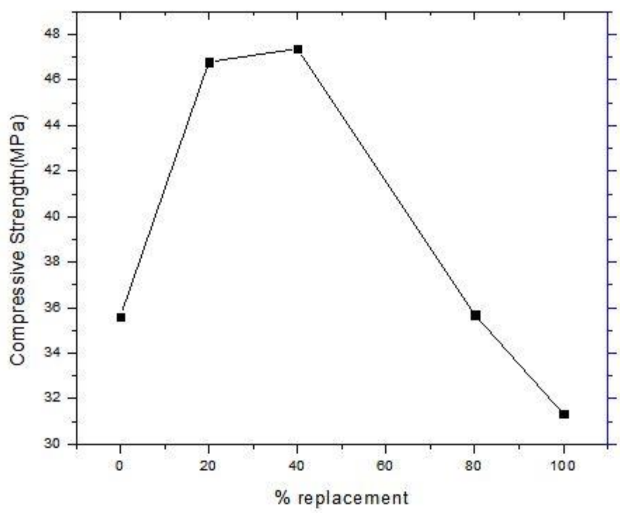

Figure 4. Compressive strength versus % replacement for 28 days.

Table 4 Compressive Strength of fly ash concrete for 28 days with 1% fiber

S. No	Nomenclature	Ultimate Load (kN)	Ultimate Stress(N/mm2)	increase in compressive strength	Decrease in compressive strength
1.	NC	815.86	36.26		
2.	FC 20	1071.95	47.65	11.39	
3.	FC 40	1085.28	48.24	11.98	
4.	FC 80	817.77	36.35	0.09	
5.	FC 100	717.81	31.90		4.36

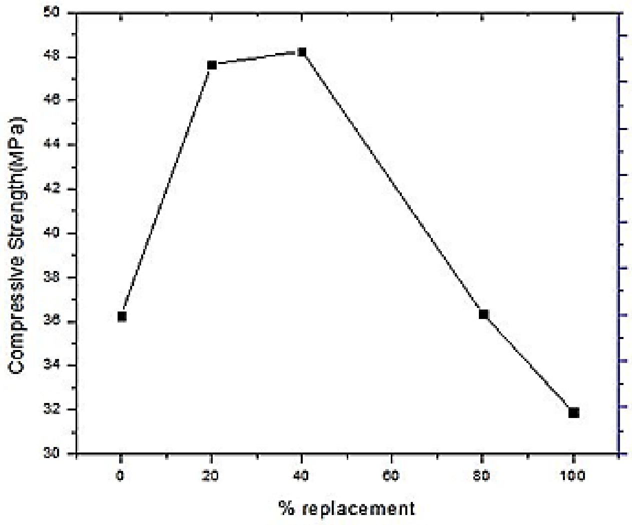

Figure 5. Compressive strength versus % replacement for 28 days

Table 5. Compressive Strength of fly ash concrete for 28 days with 2% fiber

S.No	Nomenclature	Ultimate Load(kN)	Ultimate Stress(N/mm2)	increase in compressive strength	Decrease in compressive strength
1.	NC	866.86	38.53		
2.	FC 20	1138.95	50.63	12.10	
3.	FC 40	1153.11	51.26	12.72	
4.	FC 80	868.88	38.62	0.09	
5.	FC 100	762.67	33.90		4.63

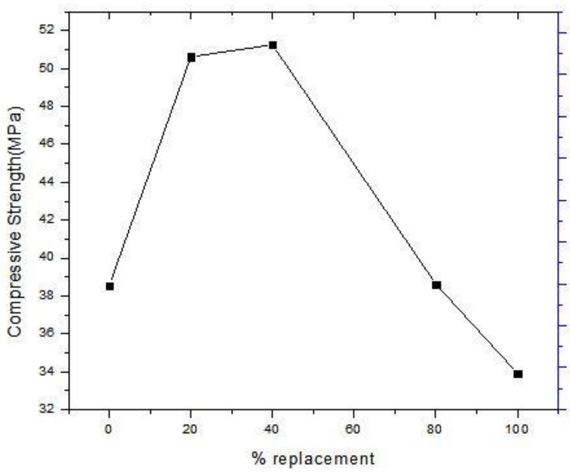

Figure 6 . Compressive strength versus % replacement for 28 days Maximum compressive strength obtained at 40% flyash in all the ages of concrete.

Table 6. Split Tensile Strength of fly ash concrete for 28 days with 0% fiber

S. No	Nomenclature	Ultimate Load(kN)	Ultimate Stress(N/mm2)	increase in compressive strength	Decrease in compressive strength
1.	NC	215.05	12.17		
2.	FC 20	220.66	12.48	0.31	
3.	FC 40	224.40	12.69	0.52	
4.	FC 80	220.66	12.48	0.31	
5.	FC 100	152.41	8.62		3.55

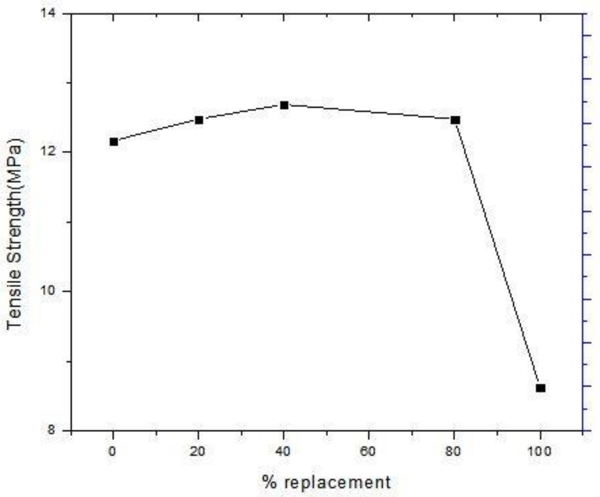

Figure 7. Tensile strength versus % replacement for 28 days

Table 7. Split Tensile Strength of fly ash concrete For 28 days with 1% fiber

S. No	Nomenclature	Ultimate Load(kN)	Ultimate Stress(N/mm2)	increase in compressive strength	Decrease in compressive strength
1.	NC	218.96	12.39		
2.	FC 20	224.67	12.71	0.31	
3.	FC 40	228.48	12.93	0.54	
4.	FC 80	224.67	12.71	0.31	
5.	FC 100	155.18	8.78		3.61

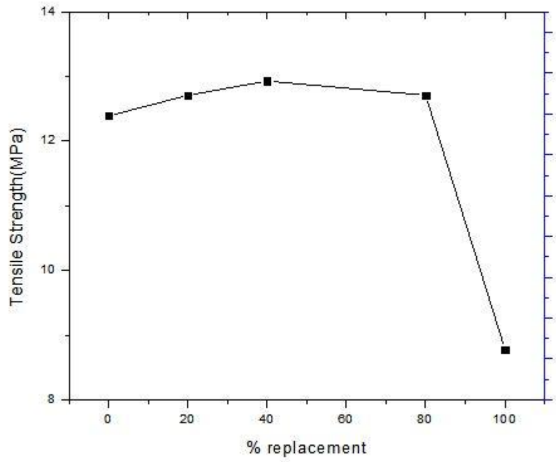

Figure 8. Tensile strength versus % replacement for 28 days

Table 8. Split Tensile Strength of fly ash concrete For 28 days with 2% fiber

S. No	Nomenclature	Ultimate Load(kN)	Ultimate Stress(N/mm2)	increase in compressive strength	Decrease in compressive strength
1.	NC	232.65	13.17		
2.	FC 20	238.71	13.51	0.34	
3.	FC 40	242.76	13.74	0.57	
4.	FC 80	238.71	13.51	0.34	
5.	FC 100	164.87	9.32		3.84

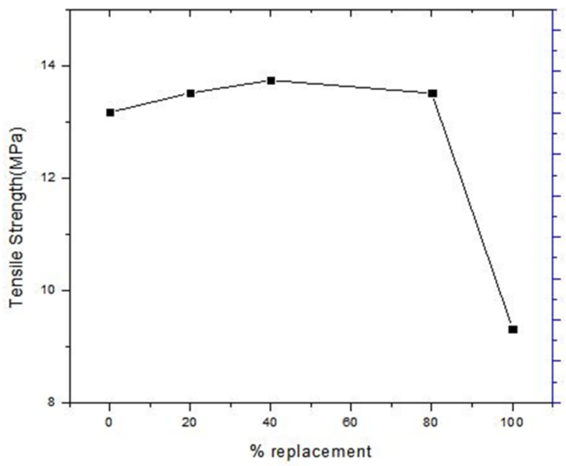

Figure 9. Tensile strength versus % replacement for 28 days Maximum Tensile strength obtained at 40% flyash in all the ages of concrete.

Table 9. Flexure Strength of fly ash concrete for 28 days with 0% fiber

S.No	Nomenclature	Ultimate Load(kN)	Ultimate Stress(N/mm2)	Decrease in flexural strength
1.	NC	28.75	5.03	
2.	FC 20	26.49	4.69	6.76
3.	FC 40	26.22	4.61	1.71
4.	FC 80	20.45	3.54	23.21
5.	FC 100	17.39	3.09	12.71

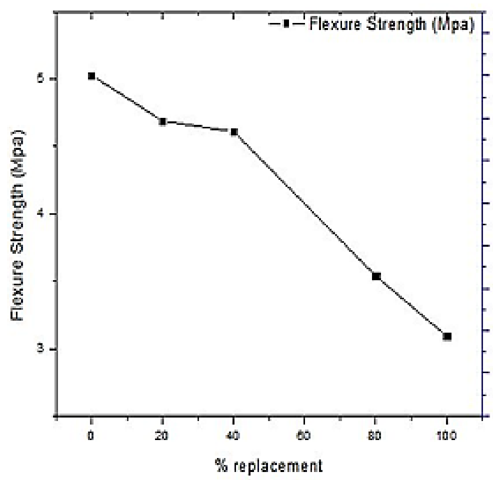

Figure 10. Flexural strength versus % replacement for 28 days

Table 10. Flexure Strength for fly ash concrete For 28 days with 1% fiber

S.No	Nomenclature	Ultimate Load(kN)	Ultimate Stress(N/mm2)	Decrease in flexural strength
1.	NC	30.54	5.43	
2.	FC 20	29.90	5.31	2.21
3.	FC 40	25.94	4.61	13.18
4.	FC 80	22.70	4.03	12.58
5.	FC 100	21.75	3.86	4.22

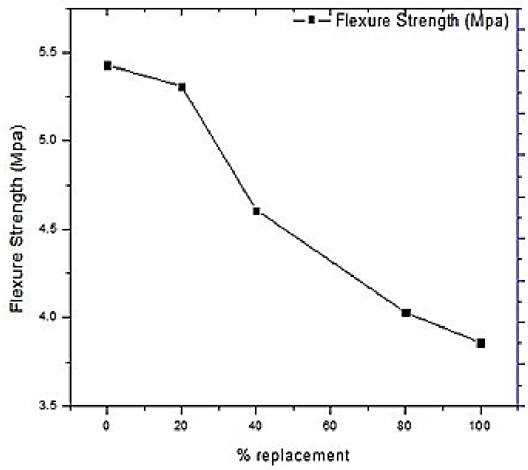

Figure 11. Flexural strength versus % replacement for 28 days

Table 11. Flexure Strength for fly ash concrete For 28 days with 2% fiber, Maximum flexural strength obtained at 0% flyash in all the ages of concrete.

S.No	Nomenclature	Ultimate Load(kN)	Ultimate Stress(N/mm2)	Decrease in flexural strength
1.	NC	32.74	5.63	
2.	FC 20	30.61	5.44	3.37
3.	FC 40	24.90	4.35	20.04
4.	FC 80	22.70	4.03	7.36
5.	FC 100	21.75	3.9	3.23

IV. CONCLUSION

The following conclusions may be drawn from the present experimental work

1. The workability of fly ash concrete decreases when compared to sand concrete.
2. The compressive and split tensile strengths increase with increase in fly ash concrete in the concrete mix up to 40% then decreases.
3. It is economical, reduces cost and eco-friendly.
4. The incorporation of fly ash upto 40% is beneficial for the concrete works.
5. This study could enlighten the local peoples to use of fly ash to sand for concrete works.
6. We can save natural resources by using fly ash to sand as it is in scarce.

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