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An Experimental Study on the Flexural Behaviour of Natural Fibre Reinforced Concrete with Partial Replacement of Flyash and GGBS

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Abstract

In this experimental work to reduce the usage of cement, supplementary cementing materials like fly ash and GGBS (Ground Granulated Blast furnace Slag) are used as cement replacing materials. The investigations are carried for the compressive test, flexural strength test on the concrete specimens. Usage of natural fibers in a relatively brittle cement matrix has attained significant toughness and strength of the composite. When comparing the 28th day cube compressive strength test results it is noticed that the Jute Fibre Reinforced Cement Concrete mix (JFRCC) with 30% GGBS has maximum compressive strength of 46.32 N/mm2 which is 8.86% higher than normal concrete and 15.8% higher than JFRCC with 30 % Fly ash. In case of JFRCC with 30 % GGBS has the maximum deflection of 20.46 mm under the moment of 2.475 kNm which is 9.09% higher than the normal RCC beam.

Keywords - *Ground Granulated Blast furnace Slag, natural fibers, brittle cement matrix, toughness, Jute Fibre Reinforced Cement Concrete mix (JFRCC).*

I. INTRODUCTION

Concrete is the most abundant manmade material in the world. The production of cement from industries emits green house gases and CO_2. The production of 1ton of cement emits approximately one ton of CO_2 and it is responsible for 65% of global warming. Most of the researchers working in concrete area to modify the concrete properties by using various cement replacing materials along with optimizing the cost of concrete. Recent advancements and research in material technology has led to the development of special concretes such as polymer concrete for high durability, fiber reinforced concrete for preventing cracks in concrete, high- and ultra high-strength concrete for applications in tall buildings and bridges, light weight concrete for reducing foundation loads, and high performance concrete for special performance requirements. It is a technological challenge in the field of the design of low cost and durable fiber reinforced cement concrete. In order to achieve this, Fibre Reinforced Concrete (FRC) can be used in structural members such as Beams, Columns, Staircase slabs and Pre-stressed Concrete structures. In this experimental work an attempt is made to replace the cement by the help of cement replacing materials such as Fly ash and GGBS in natural fibre reinforced concrete so that simultaneously the concrete can be cost effective, durable and eco friendly construction material.

II. LITERATURE SURVEY

From the experimental investigations of Shaik Asif Ali, it has been observed that, the optimum replacement of Ground Granulated Blast Furnace Slag Powder to cement and steel fiber without changing much the compressive strength is 20 % & 1.5 % respectively for M30 Grade. Test results of K. Kaviya and J. Chamundeeswari indicated that strength of concrete having cement replacement up to 15% of fly ash and 0.15% of fibre was comparable to the normal concrete mix without fly ash and fibre. The bending test results of Priy, Mohd. Usman and Sandeep Panchal indicated that the modulus of rupture of concrete increases by 50% at 0.50% jute fibre content. From the work of T. Sai Vijaya Krishna and B. Manoj Yadav it is observed that the JFRCC specimens with 1% jute content, cured up to 56 days has significant improvement of mechanical properties. From the literature study it is clear that the optimum dosage of Jute fibre preferable from the literature survey is 0.5% by weight of cement and the effective length can be maintained to 15 mm. The maximum dosage of replacement in cement should be limited to 30 %

III. MATERIALS AND METHODS

A. Cement

Ordinary Portland Cement of 53 Grade is used throughout this investigation. The cement samples were tested as per the procedure given in IS:401-1996 and IS: 4032-1999 as shown in Fig 1. The important properties of the cement from the test results are given in TABLE I.

Table I Properties Of Cement

Grade	OPC 53
Specific Gravity	3.15
Fineness	3%
Initial setting time	28 min
Final setting time	310 min

Fig 1 Testing on Cement (Standard Consistency)

B. Fine Aggregate

Locally available river sand conforming to Grading zone II of IS: 383 –1970.Weight of sample is 200g. The properties of fine aggregates were tested as per IS: 383-1970 as shown in Fig 2.The particle size distribution of Fine Aggregate is shown in Fig 3. The test results are given in TABLE II.

Table II Properties Of Fine Aggregate

Fineness modulus	2.25 %
Specific gravity	2.60
Water absorption	1%

Fig 2.Sieve Analysis

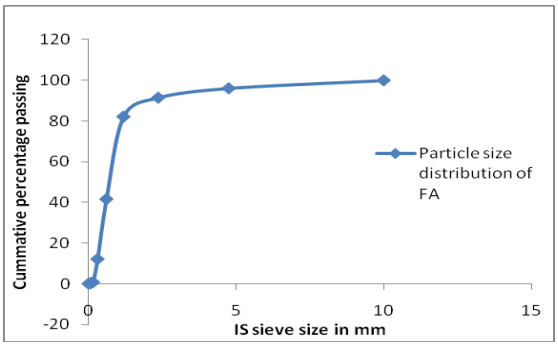

Fig 3. Particle size distribution curve of fine aggregate

C. Coarse Aggregate

Crushed granite aggregate with a maximum nominal size of 20mm have been used. The test sample of 200 g was taken the tests were carried out as per the code IS: 2386 and 383-1970. The summaries of properties of coarse aggregate are given in the TABLE III.

Table III Properties of coarse aggregate.

Fineness modulus	6.05%
Specific gravity	2.60
Water absorption	1%
Size Aggregate	20mm

D. Fly Ash

Fly ash is one of the most abundant materials on the Earth. Fly ash is the main byproduct created from the combustion of coal in coal-fired power plants. The properties of Fly ash and GGBS are compared in the TABLE IV.

E. GGBS

Ground granulated blast furnace slag comprises mainly of calcium oxide, silicon di-oxide, aluminium oxide, magnesium oxide. It has the same main chemical constituents as OPC (Ordinary Portland Cement) but in different proportions.GGBS is used to make durable concrete structures in combination with OPC (Ordinary Portland Cement) or PPC (Portland Pozzolana Cement).

Table IV Properties Of Fly Ash And GGBS

S .No	Property	Fly ash	GGBS
1	Specific Gravity	2.44	2.58
2	Fineness	227.8 g/m^2	202.7 g/m^2
3	Fineness Modulus	5	7
4	Density	1029.7 Kg/m^3	2067.06 Kg/m^3

F. Jute Fibre (Natural Fibre)

Jute Fiber is 100% bio-degradable and recyclable and environmentally friendly. Jute is the second most important vegetable fiber after cotton not only for cultivation, but also for various uses. The properties of Jute fibre are shown in TABLE V.

Table V Properties Of Jute Fiber

Diameter	0.6 mm
Fiber Length	20mm
Density	1460 kg/m^3
Tensile Strength	400-800 MPa
Stiffness	10-20 kN / mm^2

G. Super Plasticisers

In this present investigation, a super plasticizer namely CONPLAST SP 430 has been used. The rate of addition is generally in the range of 0.5 – 2 kg /100 kg cement.

IV. TESTING OF SPECIMENS

As per IS10262-2009, the obtained design mix for M40 grade concrete is1:2.35:3.2 for the water cement ratio 0.4. The super plasticizer CONPLAST SP 430 is added as 1 % by weight of cement in order to increase the workability. And to increase the toughness of the cement matrix the addition of Jute fibre is limited to 0.5% by weight of cement. In the first combination the specimen has casted with 30 % of Fly ash as a cement replacing material and in the second combination 30 % GGBS by weight of cement has been used as a cement replacing material. The behaviour of both the combination has been compared under compression and bending test.

A. Cube Compression test on concrete

The load shall be applied without shock and increased continuously at a rate of approximately 140 kg/sq cm/min until the resistance of the specimen to the increasing load breaks down and no greater load can be sustained as shown in the Fig 4. From the test results, it was observed that the maximum compressive strength was obtained for mix Combination JFRCC with 30% GGBS as shown in the Table VI

Fig 4 Cube compression test

Table 6 Compressive Strength Test Results

MIX	JUTE FIBER (%)	Compressive strength N/mm²	
		7th Day	28th Day
Normal	-	19.50	42.55
JFRCC(30 % Fly Ash)	0.5	17.09	38.97
JFRCC(30 % GGBS)	0.5	24.85	46.32

B. Bending Test on Beams

Singly reinforced beam with 10 mm diameter bar as main reinforcement and 8 mm 2 legged stirrups at 300 mm c/c as shear reinforcement is used as a test specimen in flexural or bending (two point bending) test. The test specimen shall be placed in the machine correctly centered with the longitudinal axis of the specimen at right angles to the rollers. The load shall be applied at a rate of loading of 180 kg/min. The results of flexural strength of concrete at the age of 28 days are presented in TABLE VII.

Table VII Bending Test Results Of Beam Specimens

Beam	Maximum Deflection in mm			Maximum Moment in kNm
	Right L/3	Middle (L/2)	Left L/3	
Normal Beam	16.2	17.1	16.1	2.25
JFRCC with 30% Fly ash	12.9	13.7	12.87	2.025
JFRCC with 30% GGBS	19.3	20.46	19.1	2.475

C. Results and Discussions

As From the compressive strength test of cube specimens it is noted that the JFRCC with 30% GGBS has the maximum cube compressive strength of 24.85 N/mm^2 (in 7 days) which is 21.5% higher than normal beam and 31.22 % higher than JFRCC with 30 % Fly ash. When comparing the 28th day test results it is noticed that the JFRCC with 30% GGBS has maximum compressive strength of 46.32 N/mm^2 which is 8.86% higher than normal concrete and 15.8% higher than JFRCC with 30 % Fly ash. The JFRCC with 30% FA has the compressive strength of 17.09 N/mm^2 and 38.97 N/mm^2 in 7 days and 28 days respectively. The comparison of strength in cube compression test is shown in Fig 5.

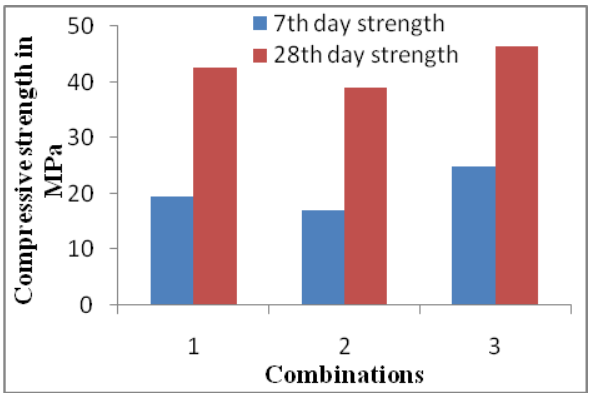

Fig 5 Interpretation of results from cube compressive strength

When comparing the results of bending test the JFRCC with 30 % Fly ash has the maximum deflection of 13.7 mm under the maximum bending moment of 2.025 kNm which is 11.1 % lower than normal beam. In case of JFRCC with 30 % GGBS has the maximum deflection of 20.46 mm under the moment of 2.475 kNm which is 9.09% higher than the normal RCC beam. The load Vs deflection behavior of JFRCC with normal RC beam under bending has been shown in the Fig 6.

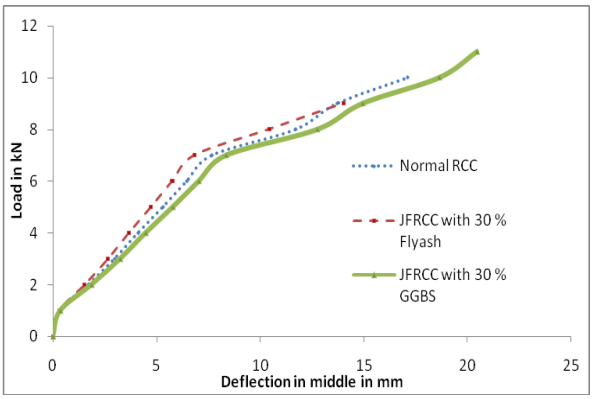

Fig 6 Interpretation of results from bending test

V. SUMMARY AND CONCLUSION

In this experimental work in order to increase the strength and toughness of the concrete mix and to reduce the cement content used in the concrete member Fly ash and GGBS are used as a cement replacing material in Natural Jute Fibre Reinforced cement concrete. And the behaviour of both materials are tested and compared with normal RCC beam. Based on the experimental investigation the following conclusions are listed below:

- From the cube compression test it is clear that the amount of GGBS added to the concrete specimen increases the compressive strength up to 21.5 % at 7 days and 8.86 % at 28 days.
- The compressive strength reduces from 14.1%-9.18% in the variation of 7-28 days when comparing with normal concrete.
- Hence it is noted that the compressive strength decreases significantly with the addition of Fly ash.
- When comparing the bending test results it is noted that the maximum deflection is 20.46 mm which is 16.4% higher than normal RCC and 33% higher than JFRCC with 30 % Fly Ash.
- It is observed that when the percentage of GGBS increases, the flexural strength of concrete also increases. On the contrary, the strength decreases when the percentage of flyash increases.

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