Performance evaluation of Steel Fibre Reinforced Concrete Beams with Bagasse Ash

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Abstract - *Plain concrete has low tensile strength and hence steel is provided. Addition of steel fibres in RC beam will increase the performance of beam. In this study, performance evaluation of Steel fibre reinforced concrete (SFRC) beams is done using bagasse ash(BA). Bagasse ash generated from sugar industry (co.generation plant) is used for partially replacing cement. M20 mix design is performed and optimal values of bagasse ash and steel fibres were determined. Beams are cast for optimum value (i.e) 10% bagasse ash which partially replace cement and 1% volume fraction of hooked end steel fibres. Beams are tested under two point loading in a loading frame of 1000 kN capacity. Load deflection behaviour of conventional and SFRC+BA beams are studied. Initial crack of SFRC+BA beams was delayed due to its ductile behaviour. 35% increase in ultimate load was observed in SFRC+BA beams. SFRC+BA beams show improved performance interms of flexure when compared to conventional beams.*

Key Words: **Bagasse Ash, Steel Fibre, Ultimate load, Deflection, Crack**

1.INTRODUCTION

Bagasse ash is generated from sugar industry. The discarded fibrous matter obtained after the process of juice extraction in sugar industry is called bagasse. This bagasse is used in co.generation plant to generate power and the residue left after the process is called baggase ash[1]. Bagasse ash blended concrete performs well in terms of strength and durability. High early strength and reduction in water permeability can be achieved using bagasse ash[4]. Bagasse ash can be used for producing high strength concrete[3].

Steel fibre act as crack arrestor in concrete matrix[5]. Various types of steel fibres like crimped & hooked end steel fibres in micro and macro form with varying aspect ratio have significant impact on the performance of RC beam. Steel fibres improve the various characteristics of beam such as stiffness, energy absorption and ductility. The combined effect of long and short steel fibres in concrete may influence the behaviour of beam.[8].

1.1 LITERATURE REVIEW

Sumrerng et.al studied the behaviour of high strength concrete using bagasse ash as partial replacement for cement. Author produced high strength concrete of strength more than 65 Mpa. Bagasse ash was used in various proportions(10%, 20 % and 30%). Author performed test on compressive strength , porosity, co.efficient of water absorption , Rapid chloride penetration test and chloride diffusion coefficient and concluded that 30 % replacement of Bagasse ash is optimum for producing high strength concrete.

Wu Yao et.al investigated the behaviour of concrete with combination of different types of fibre. Polypropylene and carbon, Carbon and steel , Steel and Polypropylene are the different combinations used.100 mm x 100 mm cubes and 100 mm x 100 mm x 500 mm beams were cast and tested for various properties like Compression, split and flexure. Toughness evaluation have been done for these hybrid fibres. By performing all these test, author concluded that carbon-steel combination gave concrete of the highest strength.

Mukesh shukla experimented the flexure behaviour of steel fibre reinforced concrete beams with two different volume fractions of one percent and two percent. Mix for 20 Mpa strength was designed. Beams of size 120 mm x 240 mm x 1900 mm were used for the study. Author gave a modified procedure for calculating ultimate strength of beam with steel fibres. Steel fibre reinforced beams show better characteristics in terms of ultimate load and stiffness when compared to conventional beams.

2.MATERIALS USED

OPC 53 Grade cement used for this study and its specific gravity was found to be 3.15. Bagasse ash were collected from Amaravathi sugar mills, Udumalpet. Fine aggregates conforming to Zone I grading and angular coarse aggregates of 20 mm were used in preparing concrete mix. Hooked end steel fibres of tensile strength 1100 N/mm^2 and aspect ratio 55.55 were used. Superplasticizer was used inorder to improve the workability of concrete .

3.MIX PROPORTION

Mix design for M20 were carried out and arrived which is given in Table 1.

Table 1 Mix Proportion

Cement (Kg/m^3)	Fine aggregate (Kg/m^3)	Coarse aggregate (Kg/m^3)	W/C (Kg/m^3)
383	717	1232	153

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4.EXPERIMENTAL PROGRAM

4.1 CASTING OF BEAM

Beams were cast for optimum value (i.e) 10% bagasse ash which partially replace cement and 1% volume fraction of hooked end steel fibres[12]. Beams of span 1500 mm and cross section 150 x 200 mm were cast and tested under two point loading. The beam consists of two 10 mm diameter bars at top and two 10 mm diameter bars at bottom. Shear reinforcement were provided with 8 mm diameter bars @ 100 mm spacing. Raw materials for concrete were mixed inside the concrete mixer. Concrete were poured into the steel mould for casting the beam. Two numbers of conventional beam and two numbers of SFRC + BA beams were cast and cured for 28 days.

4.2 TESTING OF BEAM

All the beam specimens were tested under a loading frame of 1000 kN capacity. Beams were simply supported over a span of 1200 mm. Two-point static load was applied on all beams and at load increment of 4 kN, deflection were noted. Two point loading system is used at a distance L/3 in order to get pure bending. All the beams were loaded upto their ultimate load. Slope of tangent in load deflection curve gives the value of stiffness. Ductility factor is obtained by calculating the ratio of ultimate deflection to yield deflection. Area under load-deflection curve is calculated and it gives the value of energy absorption.

5. RESULTS AND DISCUSSION

Test results of Beam were given in Table 2.

Table 2 Beam test results-Load and deflection

S.No	Name of the specimen	First crack load (kN)	Ultimate load (kN)	Ultimate deflection (mm)
1	Conventional Beam	16	52	7.32
2	SFRC + BA Beam	24	70	9.7

Load and deflection plot for conventional and SFRC+BA beams were given in Figure 1, Figure 2 and Figure 3 respectively.

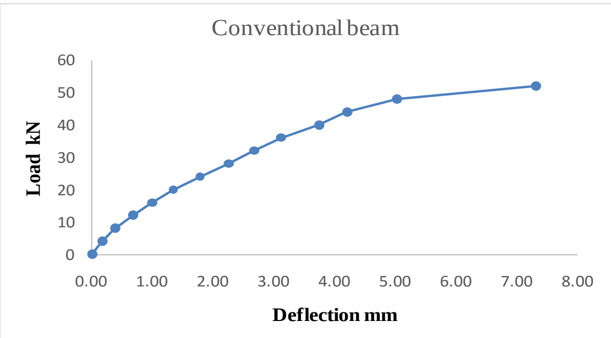

Figure 1 Load - Deflection plot for conventional beam

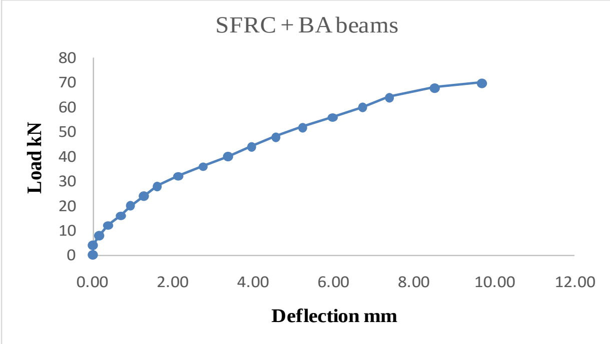

Figure 2 Load - Deflection plot for SFRC+BA beam

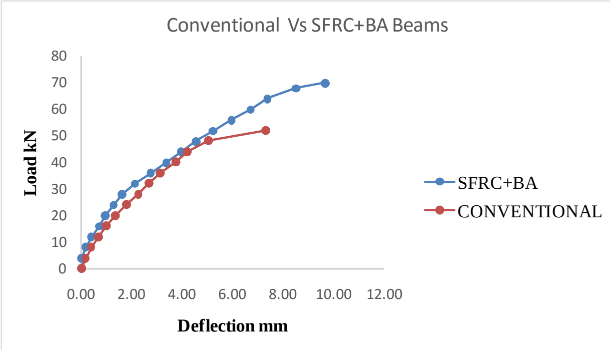

Figure 3 Comparison of Load - Deflection plot for beams

Comparison chart for first crack and ultimate load was given in figure 4.

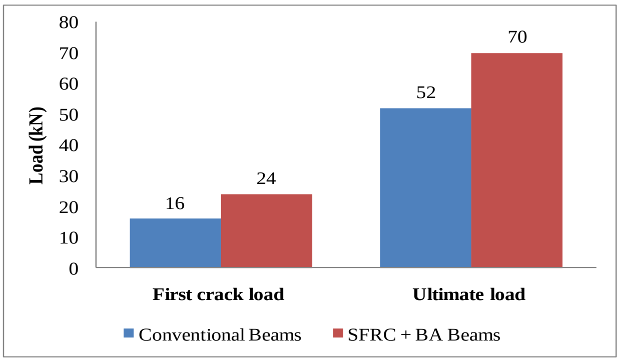

Figure 4 Comparison of First crack load and Ultimate load

Various characteristics of beam such as Stiffness, Ductility and Energy absorption were given in Table 3.

Table 3 Beam test results - Stiffness, Ductility and Energy absorption

S.No	Name of the specimen	Stiffness kN/mm	Ductility factor	Energy absorption kNmm
1	Conventional Beam	25	3.52	250
2	SFRC + BA Beam	60	7	440

- For conventional beams, initiation of crack take place at a load of 16 kN whereas for SFRC+BA beams, it is 24 kN. This shows the ductile behaviour of SFRC+BA beams
- In conventional specimen, ultimate failure took place at a load of 52 kN and for SFRC+BA it is 70 kN. 35% increase in ultimate load was observed.
- Crack patterns were occurred in flexure zone.
- Stiffness of SFRC+BA beam is 2.4 times more than that of conventional beam.
- Ductility factor of SFRC+BA beam is 2 times more than that of conventional beam.
- Energy absorption capacity of SFRC+BA beam is 1.7 times more than that of conventional beam.

6. CONCLUSION

SFRC combined bagasse ash improved the performance of beam interms of flexure when compared to conventional beam. Utilisation of bagasse ash in concrete will avoid the disposal problem of ash which minimise the cement production and thereby reducing the emission of carbon-dioxide. Fibres improved the ductility characteristics of beam and act as crack arrestors.

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