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Mechanical Properties of Hybrid Fibre Reinforced Concrete Specimens using Bagasse Ash

Gunasekaran M A[1], GokulPrasad T[2], Dhanraj M[3], Vijayakumar T[4], Angu Senthil K[5]

UG Student, Department of Civil Engineering, K.S.Rangasamy College of Technology, Tiruchengode, India[1,2,3,4]

Assistant Professor, Department of Civil Engineering, K.S.Rangasamy College of Technology, Tiruchengode, India[5]

Abstract: Concrete is a widely used construction material. Cement in concrete during manufacture emits more amount of CO_2 into atmosphere. Hence in order to reduce the consumption of cement industrial by products can be utilized in concrete. Bagasse ash is an ash generated from co-generation plant in a sugar industry. Disposal of Bagasse ash concrete creates many problems so it can be partially replaced for cement. Also, it possess pozzolanic properties. Structures constructed in seismic zone need special attention. Utilization of fibre in concrete improve the ductility of concrete. Attempt has been made to study the mechanical properties of concrete using hybrid fibres and Bagasse ash. Both Natural Fibre (sisal) and artificial Fibre (Polypropylene) are combined and utilized in concrete along with Bagasse ash. M20 mix design were carried out. Proportion of Bagasse ash (10%) and Polypropylene fibre (0.5%) are Kept constant and sisal fibre is varied in different proportion (0%, 0.1%, 0.2%, 0.3%) respectively. Mechanical properties such as Compressive strength, split tensile Strength and Flexural Strength are Studied. 10% Bagasse ash, 0.5% polypropylene fibre and 0.2 % Sisal fibre is found to be optimum.

Keywords: Bagasse Ash, Polypropylene Fibre, Sisal Fibre, Fibre Reinforced Concrete.

I. INTRODUCTION

Although, Concrete is considered as a brittle material it has been used in large scale construction due to its various advantages like high mechanical strength, easy production with relatively low cost. However, it produces low deformation capacity and rapid propagation of cracks occur, when it is subjected to tensile stresses [1,2]. In-order to minimize this limitation, dispersed fibres can be used into the cementitious matrices, which act as bridges in the region of the crack by transferring the stresses and making the fibre reinforced concrete more efficient. Consequently, the energy absorption capacity is increased with the reduction of propagation and expansion of the formed cracks [2-4]. Higher flexural toughness, fatigue resistance and impact strength is obtained with the addition of various discrete fibres like steel, polypropylene, polyester and glass fibres [5]. Hybrid fibre reinforced concrete helps to improve all the properties of concrete by combining the benefits of each fibres. Polypropylene fibres (PP) are widely used as reinforcement in concrete due to its lightweight, high strength, ease of handling, ductility and durability properties [6-7]. The incorporation of PP fibres to concrete provides Freeze-thaw resistance, impact resistance and resistance to plastic shrinkage during curing [7]. Natural fibres can be used in concrete as it is obtained from renewable sources which exist in abundance and are available at low cost. When compared to other natural fibres, sisal fibres provide a better durability property [8].
India is the second largest sugar production across globe with 500 operational sugar mills, contributing over 45% of overall production in Sugar Cane Bagasse Ash (SCBA) across globe [9,10]. The fibrous material obtained after the extraction of sugar from sugarcane, it is reused as fuel in boilers for power generation and the residue left behind is known as Sugar Cane Bagasse Ash [11]. However, it has been considered as a waste and being deposited in landfills causing an environmental burden [12]. In order to overcome this disposal problems, this type of agro waste can be used as pozzolanic in concrete. Due to the pozzolanic reaction with calcium hydroxide produced from primary hydration of cement, addition of SCBA has a positive influence on mechanical and durability properties of concrete [13]. Hence, the objective of this experimental study is to evaluate the mechanical properties of hybrid fibre reinforced concrete with an optimum percentage of SCBA.

II. LITERATURE STUDY

From the review of literature, the following salient points were observed.

- The maximum % of replacement of cement with bagasse ash is found to be up to 30% for high strength concrete
- The presence of sisal fibre at any dosage, increases the durability of concrete.
- Polypropylene fibre reinforced concrete shows improved impact resistance as compared to conventionally reinforced brittle concrete.
- SCBA replacement will develop high early strength and resistance to chloride penetration and diffusion.

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III. EXPERIMENTAL PROGRAM

A. Materials used: OPC 53 Grade cement was used in this study. Bagasse ash was collected from Bannari amman sugar mills, Bannari and used as partial replacement of cement. Fine aggregates (M - sand) passing through 2.36 mm sieve and coarse aggregates of 20 mm were used. Polypropylene fibres of aspect ratio 100 obtained from Ms. Vrukshacomposites and Sisal Fibres of aspect ratio 133.33 obtained from Ms. Kovai Green Field were used in concrete are shown in Fig. 1. and Fig. 2., respectively. Superplasticizer CeraPlast 300 of sulphonated naphthalene polymers was used by 1% of weight of cement to improve the workability of concrete. Table.1 shows the properties of Fibres

Fig. 1 Polypropylene fibre

Fig. 2 sisal fibre

Table.1 Properties of Fibre

Properties	Polypropylene fibre	Sisal fibre
Length (mm)	12	12
Diameter (mm)	0.012	0.09
Aspect ratio	100	133
Density (kg/m^3)	980	1580

B. Mix Proportion: M20 - Mix design was calculated based on the guidelines recommended in IS 10262:2019 and IS 456:2000. Mix proportion of 1 : 2 : 3.67 and w/c ratio of 0.45 were used in this experimental investigation and are shown in table 2

Table. 2 Mix proportion

Mix ID	Cement (Kg/m^3)	Bagasse Ash (Kg/m^3)	Fine Aggregate (Kg/m^3)	Coarse Aggregate (Kg/m^3)	Polypropylene Fibre Vol (%)	Sisal Fibre Vol (%)	Water (Kg/m^3)
CC	338	338	690	1243	-	-	152
BAC10	338	304.2	690	1243	-	-	152
PPFRCBA	338	304.2	690	1243	0.5	0	152
HFRCBA1	338	304.2	690	1243	0.5	0.1	152
HFRCBA2	338	304.2	690	1243	0.5	0.2	152
HFRCBA3	338	304.2	690	1243	0.5	0.3	152

B. Test for compressive Strength: Bagasse ash were used for partially replacing cement at Constant proportion 10% and polypropylene fibre at constant proportion of 0.5% and sisal fiber for different volume fraction (0%, 0.1%, 0.2%, 0.3%) were used. 36 numbers of cube specimen (150 x 150 x 150 mm) were casted and tested in Compression testing machine.

C. Test for split tensile strength: Bagasse ash were used for partially replacing cement at Constant proportion 10% and polypropylene fibre at constant proportion of 0.5% and sisal fiber for different volume fraction (0%, 0.1%, 0.2%, 0.3%) were used. 36 numbers of cylinder (150 x 300 mm) were casted and tested.

D. Test for flexural strength: Bagasse ash were used for partially replacing cement at Constant proportion 10% and polypropylene fibre at constant proportion of 0.5% and sisal fiber for different volume fraction (0%, 0.1%, 0.2%, 0.3%) were used. 36 numbers of prism (500 x 100 x 100 mm) were casted and tested.

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IV. RESULT AND DISCUSSION

E. Compressive Strength

Table.3 shows the test results of compressive strength. Concrete specimen containing 0.5% volume fraction of polypropylene fibre with 10% Bagasse ash shows better performance with 14.52% increase in compressive strength. Addition of 0.1% volume fraction of sisal and 0.5% volume fraction of polypropylene fibre with 10% Bagasse ash shows slight increase in strength of concrete. Thus, from Fig 3 it can be seen that further increase in volume fraction of sisal fibre shows marginal increase in strength up to 0.2% and decreases from 0.3%.

Table.3 Compressive strength

S. No	% Replacement of bagasse ash	% Replacement of polypropylene fiber	% Replacement of sisal fiber	Compressive strength @ 7 days MPa	Compressive strength @ 28 days MPa
1	0	0	0	19.25	27.50
2	10	0	0	21.66	30.95
3	10	0.5	0	22.05	31.50
4	10	0.5	0.1	22.47	32.10
5	10	0.5	0.2	23.40	33.43
6	10	0.5	0.3	22.41	32.02

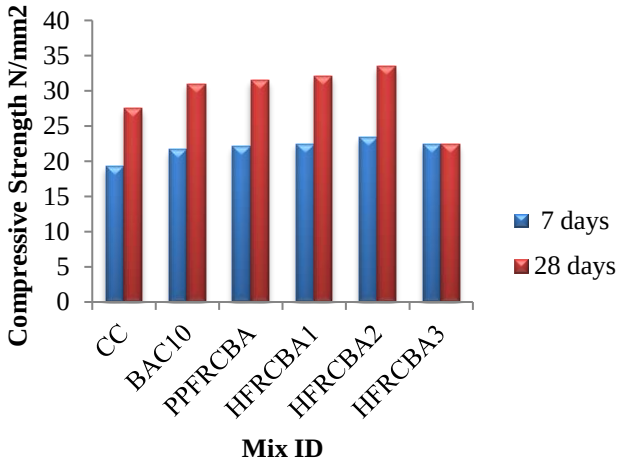

Fig. 3 Compressive strength

F. Split tensile strength

Table.4 shows the test results of split tensile strength. Concrete specimen containing 0.5% volume fraction of polypropylene fibre with 10% Bagasse ash shows better performance with 22.81% increase in compressive strength. Addition of 0.1% volume fraction of sisal and 0.5% volume fraction of polypropylene fibre with 10% Bagasse ash shows slight increase in strength of concrete. Thus, further increase in volume fraction of sisal fibre shows marginal increase in strength up to 0.2% and decreases from 0.3% which is represented in Fig.4.

Table.4 Split tensile Strength

S. No	% Replacement of bagasse ash	% Replacement of polypropylene fiber	% Replacement of sisal fiber	Split tensile strength @ 7 days MPa	Split tensile strength @ 28 days MPa
1	0	0	0	1.87	2.63
2	10	0	0	2.23	3.10
3	10	0.5	0	2.31	3.23
4	10	0.5	0.1	2.38	3.46
5	10	0.5	0.2	2.42	3.51
6	10	0.5	0.3	2.39	3.44

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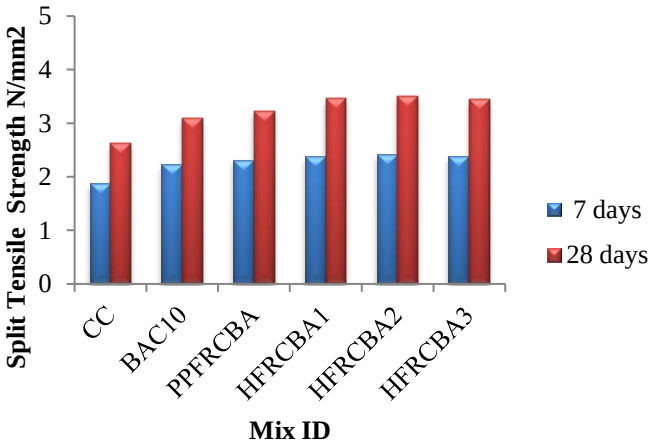

Fig. 4 Split tensile Strength

G. Flexural strength

Table.5 shows the test results of Flexural strength. Concrete specimen containing 0.5% volume fraction of polypropylene fibre with 10% Bagasse ash shows better performance with 11.29% increase in compressive strength. Addition of 0.1% volume fraction of sisal and 0.5% volume fraction of polypropylene fibre with 10% Bagasse ash shows slight increase in strength of concrete. Thus, further increase in volume fraction of sisal fibre shows marginal increase in strength up to 0.2% and decreases from 0.3% which is represented in Fig 5.

Table.5 Flexural strength

S.No	% Replacement of bagasse ash	% Replacement of polypropylene fiber	% Replacement of sisal fiber	Flexural strength @ 7 days MPa	Flexural strength @ 28 days Mpa
1	0	0	0	2.72	3.1
2	10	0	0	2.32	3.32
3	10	0.5	0	2.44	3.45
4	10	0.5	0.1	2.60	3.61
5	10	0.5	0.2	2.62	3.69
6	10	0.5	0.3	2.51	3.60

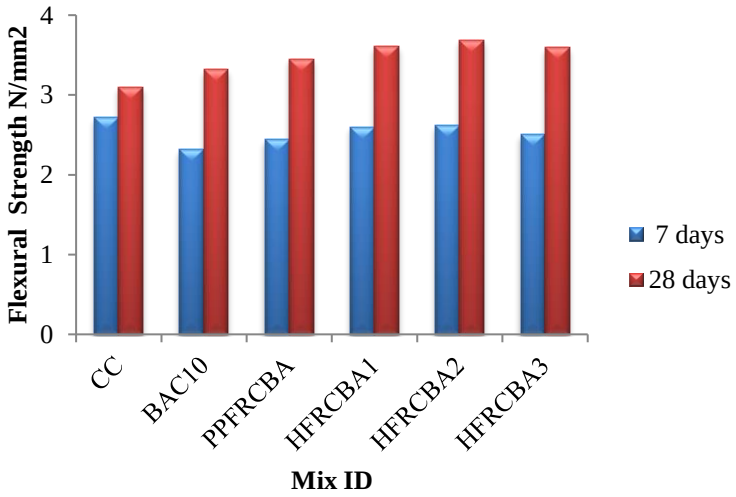

Fig. 5 Flexural strength

V. CONCLUSION

- 10% Bagasse ash with 0.2% and 0.5% volume fraction of sisal and polypropylene fibre respectively is found to be optimum.
- For 0.2% and 0.5% volume fraction of sisal and polypropylene fibre, 21.53% increase is observed in compressive strength when compared to controlled concrete specimen.
- Split tensile strength of concrete increases 33.46%, for mix of 0.2% and 0.5% volume fraction of sisal and polypropylene fibre when compared with controlled concrete specimen.
- When compared to controlled concrete specimen, at 0.2% and 0.5% volume fraction of sisal and polypropylene fibre recorded 19.03% increase in flexural strength.
- Use of Bagasse ash will minimize the consumption of cement quantity and it can overcome environmental issues.
- Mechanical properties of concrete specimen can be improved by partially replacing bagasse ash for cement and adding hybrid fibre at suitable dosage.

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