 https://doi.org/10.1051/e3sconf/202130901112

Studies on effect of sugarcane bagasse fibre on mechanical properties and workability of low calcium fly ash and slag based geopolymer concrete.

*T.*Srinivas[1], *Srimanthula* Chandana [2] and *N V* Ramana Rao [3]

[1]Professor, Départment of Civil Engineering, GRIET, Hyderabad, India
[2]PG Student,, Départment of Civil Engineering, GRIET, Hyderabad , India.
[3]Professor, Départment of Civil Engineering, JNTU, Hyderabad, India.

Abstract. Individuals from the group of inorganic polymers are known as geopolymers. The geopolymer material's compound organisation is similar to that of typical zeolitic materials, however the microstructure is undefined rather than translucent. The polymerisation interaction includes a considerably quick substance response under antacid condition on Si-Al minerals and that meets the basic properties of concrete as well as falls under classification of manageability. Utilization of various fibres like steel, glass, sugarcane bagasse etc, significantly influences fresh and hardened properties of concrete. Sugarcane bagasse fibre is a by-product from sugar industries and can be used as a fibre in concrete. The target of this paper is to study an effect of sugarcane bagasse fibre on mechanical properties such as compressive, tensile and flexural sgength and also the workability of low calcium fly ash (Class-F) and slag based geopolymer concrete of G40 grade which is équivalent to M40.. Sugarcane baggase ash fibre has been used for both the concencrte G40 and M40 as 0.5%,1%,1.5%,2%. All the samples were casted and oven cured at 60o for 24 hours after one day rest period and remaining days cured in an ambient temperature, then tested on 3rd, 7th and 28th day to assess the mechanical properties, such as Compressive, Tensile, and Flexure strength. The results were compared among controlled concrete (CC), controlled concrete with sugarcane bagasse fibre (CCF), geopolymer concrete (GPC) and geopolymer concrete with sugarcane bagasse fibre (GPCF). The results revealed that with addition of SCBF, the mechanical properties have been enhanced significantly.

I Introduction

It is only second to water in terms of widespread use on the planet. Generally, “ordinary Portland concrete (OPC) is used as the primary cover for delivering concrete. The environmental challenges surrounding the production of OPC are noteworthy”. The amount of carbon dioxide released during OPC assembly as a result of limestone calcination and non-renewable energy source combustion is expressed as a request for one tonne for each massive load of OPC delivered. Furthermore, the amount of energy required to deliver OPC is comparable to that required to deliver steel and aluminium. However, the widespread availability of fly debris allows for the use of this product of coal consumption as a substitute for OPC in the fabrication of concrete. “Fly ash reacts with the calcium hydroxide during the hydration interaction of OPC to shape the calcium silicate hydrate (C-S-H) gel when used as a fractional replacement for OPC in the presence of water and at room temperature”. The turn of events and use of high-volume fly-ash concrete, which enabled OPC to be replaced up to 60% by mass, is a significant improvement. “Natural fibre reinforced composites have poor wetting ability, high energy absorption, and poor fibre matrix adherence in general, alkali treatment has been deemed a good strategy for improving the mechanical properties of these composites by modifying the surface of the fibre to achieve greater adhesion between the fibre and the matrix”. The findings of a study aimed at generating structural elements built of bagasse polymer composite materials are presented in this article. The study's ultimate goal is to develop composite panels that may be utilised to beautify the floors and walls of a home or a low-rise commercial construction. As a first step toward that goal, hot pressing samples of bagasse composite panels were designed and manufactured. These samples were then examined for stiffness, strength, and failure mode using density, three-point bending, and compression tests. Furthermore, experiments were conducted to determine the short fibre effect with a combination of fibre and granules with a combination of fibre and granules with a combination of fibre and granules with a combination of fibre and gran. As a result of the hydration process, the major binder formed is a C-S-H gel. When this study began in 2001, there were various articles available and that described pastes of geopolymer and coating of geopolymer materials. However, there was little information available in the public domain about the geopolymer usage in innovation to create low calcium (ASTM Class F) fly ash-based geopolymer concrete. “This investigation is devoted to the development, manufacture, and design properties of a novel and solidified cement of low-calcium fly debris (ASTM Class F) and slag-based geopolymer concrete”. The sugarcane bagasse preparation was the starting point for the experiment (Figure 1). Bacteria can be found in bagasse, which can generate an unpleasant odour. To get rid of the odour, the bagasse was soaked in 90 percent sodium hydroxide for 24 hours, then dried in air at room temperature for 48 hours before going into an oven to dry for 30 seconds at 200 degrees Celsius.

2 Materials

2.1 Cement

OPC 53 grade cement is taken Penna cement brand is used.Determined by conducting specific gravity bottle testin accordance to IS:4031-1968 and conformation of specifications with IS:12629-1987 .

2.2 Fine aggregate

River sand (FA) is taken from nearby sources.the sand clean from debries,siltand clay and sieved on 4.75mm IS sieve.the physical properties are tested.

2.3 Coarse Aggregate

20mm size aggregates i.e. the aggregates which are passing through 20mm sieve and retaining on 10mm sieve have been tested as per IS IS:2386 -1968 . Various tests have been done on these aggregates such as bulk density, specific gravity etc. by using PYCNOMETER test. The specific gravity of coarse aggregate is found to be 2.62. The physical properties of coarse aggregate are examined in line with IS: 2386-1963, including specific gravity, bulk density, flakiness, and elongation index. Table 4 displays the findings of coarse aggregate. Elongated and flaky particles account for 20% and 16.47% of the coarse aggregate weight, respectively. Because the indices are within 10% to 25%, the coarse aggregate used in concrete mixtures is regarded ideal.

2.4 Fly Ash

The Class F-fly ash obtained from the Bolaram RMC plant in Andhra Pradesh is used in the current investigation. Blain's Penetrability Apparatus measures the specific surface space of fly debris to be 4750 cm2/gm. Tables 5 and 6 show the standard formation of fly ash as well as the conditions for substances.

2.5 Ground Granulated Blast Furnace Slag

Ground Granulated Blast Furnace Slag (GGBS) displayed in fig 2 is a side-effect of the steel business. Impact heater slag is characterized as "the non-metallic item comprising basically of calcium silicates and different bases that is created in a liquid condition all the while with iron in an impact heater". About 15% by mass of covers was supplanted with GGBS

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Table: 1 GGBS Chemical Composition

S.no	Characteristics	Result
1	Bulk Density kg/m3	1100
2	Fineness(Blaine’s) m2/kg	450
3	Glass content percent	93
4	Specific Gravity	2.91
5	Colour	Dull white

2.6 Water

According to IS: 456:2000, water liberated from synthetic chemicals, lubricants, and various forms of contaminants must not be used for concrete blending.

2.7 Geopolymers

Geopolymers are a chain structure framed on a spine of Al and Si particles that belong to the group of inorganic polymers. The substance arrangement of this geopolymer material is similar to that of conventional zeolitic materials, however it has an unclear microstructure rather than being translucent (Palomo, Grutzeck et al. 1999; Xu and van der Heijden 2000). (Deventer 2000).

Table: 2 Physical Properties of GGBs

S.no	Constituent	Percentage
1	Chlorides (Cl)	0.006
2	Alumina tri-oxide (Al2O3)	18.3
3	Silicon dioxide (SiO2)	33.2
4	Ferric oxide (Fe2O3)	0.6
5	Potassium oxide (K2O)	0.91
6	Sodium oxide (Na2O)	0.21
7	Magnesium Oxide (MgO)	11.6

 https://doi.org/10.1051/e3sconf/202130901112

8	Sulphur tri-oxide (SO3)	1.0
9	Calcium oxide (Cao)	32.9

2.7.1Constituents of Geopolymer

2.7.1.1Source Materials

Any material containing Silicon (Si) and Aluminum (Al) and has a shapeless structure is a suitable source material for geopolymer assembly. “A few minerals and mechanical side-effect materials with regular Al-Si minerals have shown the potential to be source materials for geopolymerisation, though quantitative expectations on the reasonableness of the particular mineral as the source material are still not available due to the complexity of the response instruments used (Xu and van Deventer 2000)”. Only fly debris and slag have emerged as possible source materials for geopolymer production among the results. The molecular size, unclear substance, morphology, and the commencement of fly ash were all factors that influenced the suitability of fly ash as a source material for geopolymers.

2.7.1.2 Alkaline Activators

“A sodium hydroxide (NaOH) mixture or potassium hydroxide (KOH) and sodium silicate (Na2SiO3) or potassium silicate (K2SiO3) is the most well-known basic activator used in geopolymerisation (Davidovits 1999; Palomo, Grutzeck et al 1999; Barbosa, MacKenzie et al 2000; Xu and van Deventer 2000; Swanepoel and Strydom 2002; Xu and van Deventer 2002)”. The use of a single soluble activator has been explained (Palomo, Grutzeck et al. 1999; Teixeira-Pinto, Fernandes et al. 2002). “Palomo et al (1999) hypothesised that the kind of activator plays an important role in the polymerisation interaction, when the basic activator comprises solvent silicate, either sodium or potassium silicate, responses occur at a faster rate than when only soluble hydroxides are used”. The inclusion of sodium silicate as a basic activator for the sodium hydroxide arrangement increased the reaction between the source material and the arrangement, according to Xu and van Deventer (2000). Based on an investigation of the geopolymerisation of sixteen common Al-Si minerals, they discovered that the NaOH arrangement caused more mineral disintegration than the KOH arrangement.

2.7.1.3 Superplasticiser

To improve the usefulness of the new geopolymer concrete, high effective reducing of water (Master Glenium B233) super plasticizer was used in the mix at a rate of 1.5 percent by weight of binder. For M40 and G40, naphthalene formaldehyde sulphonate (SNF) is utelized.

2.7.1.4 Sugarcane Baggase

Bagasse pre-treatment has been proven to be beneficial in improving absorbability and providing, “an easy access for microbial attack (by removing the centre and noncore lignin sections) (Alani and Smith, 1988; Doran et al, 1994)”. The pretreatment increases the inward surface space of the substrate particles by partially solubilizing or perhaps corrupting hemicellulose and lignin. This causes the three sections to be fractionated, as well as the cellulose structure to be opened. Steam blast, gamma radiation, therapy with soluble base, hydrogen peroxide, solvents, and other physical and synthetic procedures are used for the pre-treatment, which include steam blast, gamma radiation, therapy with soluble base, hydrogen peroxide, solvents, and so on. Compound pre-medicines (for example, treatment with a soluble base such as NaOH arrangement) have been found to be both elective and practical.The current survey focuses on the properties and substance organization of bagasse filaments. It is challenge to the making of better materials for the improvement of personal satisfaction with better mechanical properties. The current survey likewise centers around the actual properties, mechanical properties, fiber types,
substance arrangement of bagasse filaments. The goal of the present investigation is to use the benefits offered by inexhaustible assets for the improvement of composite materials dependent on bagasse. It is challenge to the creation of better materials for the improvement of value of existence with better mechanical properties.
“Bagasse was cut into pieces around 10 mm long, and absorbed 1, 2 or 3 % NaOH arrangement (wt/v) for 2 h. The strands were flushed with refined water until the washed arrangement arrived at a pH of 7.0. The basic treated strands were dried at 80OC for 15 h, then, at that point moved into fixed plastic sacks and kept in a desiccator until utilized”.

Figure 1

3 Experimental Investigation

This paper is to create and streamlining of strength of concrete M40 and G40 grades of low calcium fly debris (Class-F) and slag based geopolymer . The advancement of blend configuration depends on many factors, for example, soluble fluid to fly debris proportion, Na2SiO3 to NaOH proportion, molarity of NaOH, kind of relieving strategies, temperature and rest period and so on The substantial blend is planned by utilizing all the above boundaries and examples were casted then tried on 3, 7and 28th day as per codal strategies. The arrangement of test of specimen of 100mm*100mm*100mm for every creation were projected for testing compressive strength then following one day rest period, a big part of the examples were restored in a broiler at 60°C for 24hours and for the leftover time frame relieved under daylight until the testing is done and staying half of sample were surrounding restored. The examples were tried on third, seventh and 28th day as indicated by codal strategies. The outcomes are organized and the necessary similar investigation is finished.

Table 3: Properties of Na2SiO3 Solution

Molar mass	40 gm/mol
Appearance	White solid
Density	2.1 gr/cc
Melting point	318oC
Boiling point	1390oC
Heat liberated amount when water dissolved	266 cal/gr

Table 4 NaOH : Properties

Specific gravity	1.57
Mass of Molarity	122.06 gm/mol
Na2O (by mass)	14.35%
SiO2 (by mass)	30.00%
Water (by mass)	55.00%
Ratio of Weight (SiO2 to Na2O)	2.09
Ratio of Molarity	0.97

Table5: Mix proportions of M40 (CC)

Concrete Ingredients per m^3	
Cement (kg/m3)	386
Fine Aggregate (kg/m3)	684
Coarse Aggregate (kg/m3)	1198.114
Super plasticizer	1.5%
Mix proportions Ratio	1:1.77:3.10
W/C ratio	0.40
Workability in terms of Slump (mm)	75-100mm

Table6: Mix proportions G40 (GPC)

Concrete Ingredients per m^3	
Fly Ash (kg/m3)	327.25
GGBS (kg/m3)	57.75
Fine Aggregate (kg/m3)	684
Coarse Aggregate (kg/m3)	1198.114
Super plasticizer	2%
Noah(kg/m3) 12M	44
Na2SiO3(kg/m3)	110
Mix proportions Ratio	1:1.786:3.128
W/C ratio	0.40
Water content	28.174
Workability in terms of Slump (mm	75-100 mm

Table 7: Composition of 66.7 Aspect ratio

4. Test Results

The below results have achieved at 2% of superplasticizer workability and which comparision of two Aspect ratio as 44.1,66.7 of sugarcane bagasse fibre of 0.5%. Hence workability ranges 75mm-100mm SLUMP.

Type of mix	**Fibre %**
Trail 1	0.25
Trail 2	0.5
Trail 3	0.75
Trail 4	1.0

Table8 : Compressive Strength of Controlled and Geopolymer concrete

	Compressive Strength (MPa)				
Type of mix	**3 Days**	**7 Days**	**28 Days**	**Slump (mm)**	**S.P%**
CC	25.12	33.88	48.40	65	1%
GPC	41.8	44.72	49.12	40	
CC	**24.61**	**34.51**	**49.22**	**95**	**1.5%**
GPC	41.12	45.77	49.76	70	
CC	24.31	34.52	50.75	115	2%
GPC	**42.85**	**47.48**	**50.52**	**92**	

Table9 : Controlled Concrete Fibre (CCF)

Percentage (%) of FIBRE	**TYPE OF MIX**	**Compressive Strength(MPa)**			**SLUMP with 1.5%of S.P**
		3 days	**7 days**	**28days**	
0%		24.61	34.51	49.22	95
0.25	Trail1	26.22	36.58	52.45	91
0.5	**Trail2**	**27.65**	**38.84**	**55.30**	**85**
0.75	Trail3	26.51	37.14	53.06	72
1.0	Trail4	25.37	35.52	50.75	54

Table10 :Geopolymer Concrete Fibre(GPCF)

Percentage %	**Type of mix**	**Compressive Strength (MPa)**			**SLUMP with 2% S.P**
		3days	**7days**	**28days**	
0%		42.85	47.48	50.52	92
0.25	Trail1	44.78	48.53	52.75	86
0.5	**Trail2**	**48.28**	**52.59**	**56.80**	**81**
0.75	Trail3	46.11	49.91	54.25	68
1.0	Trail4	43.69	47.28	51.40	49

Table 11.Optimum Results Compressive Strength in (MPa)

Grade of concrete	**3 Days**	**7 Days**	**28 Days**
CC	24.61	34.51	49.22
GPC	42.85	47.48	50.52
CCF	27.65	38.84	55.30
GPCF	48.28	52.59	56.80

Table 12. Split Tensile Strength in (MPa)

Concrete type	**3 Days MPa**	**7 Days MPa**	**28 Days MPa**
CC	2.13	3.20	4.39
CCF	2.45	3.678	4.90
GPC	3.64	3.94	4.41
GPCF	4.18	4.52	4.97

Table 13.Flexure Strength in (MPa)

Concrete type	**3 Days MPa**	**7 Days MPa**	**28 Days MPa**
CC	2.24	3.36	4.49
CCF	2.45	3.67	5.12
GPC	3.64	3.94	4.51
GPCF	4.18	4.52	5.18

Sugarcane bagasse fibre content has different fibre percentages of 0.25%,0.5%,0.75%,1.0%

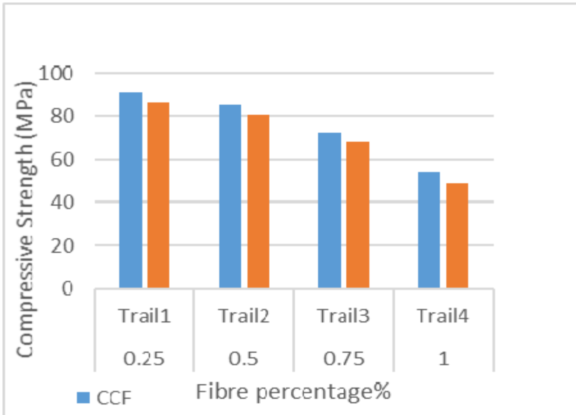

Figure1:Slump of CCF,GPCF

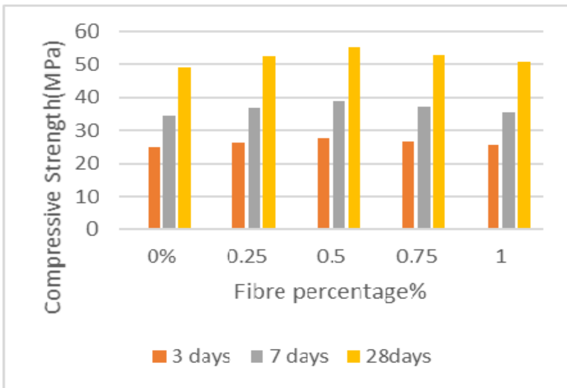

Figure 2: Compressive Strength different trails (CCF)

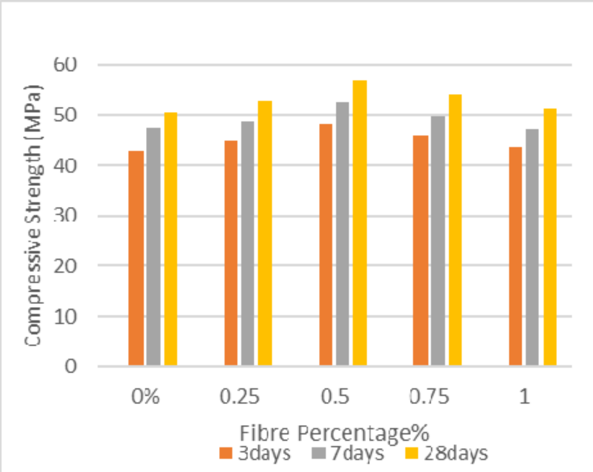

Figure3: Compressive Strength of different trails(GPCF)

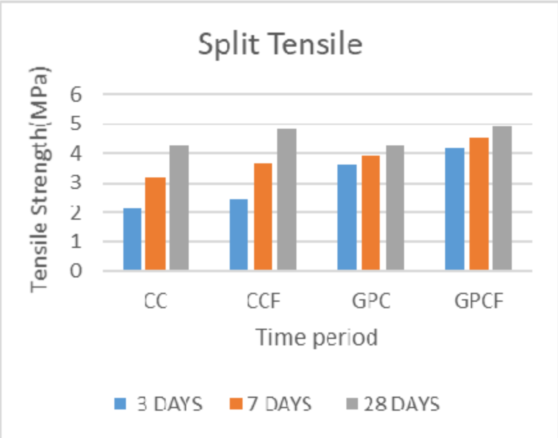

Figure4: Split tensile strength of CC,GPC with and without fibre

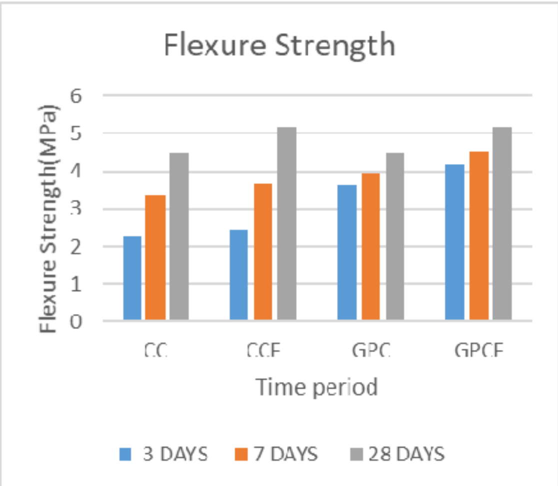

Figure5: Flexure strength of CC,GPC with and without fibre

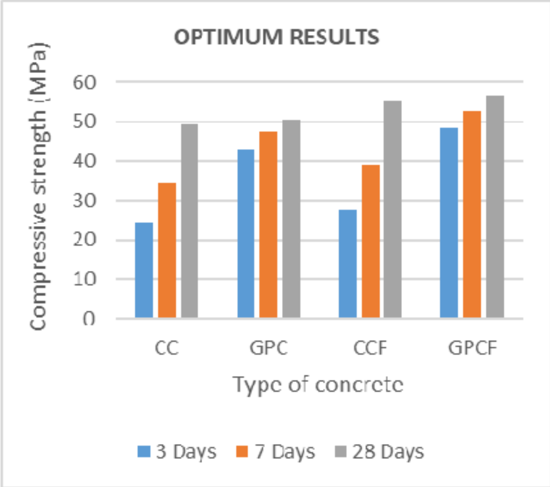

Figure6: Optimum Results of Compressive Strength

5. Conclusions

The following precise conclusions have been drawn from the experimental investigations:

1. For controlled and geopolymer concrete, the needed workability is attained at 1.5 percent and 2% superplasticizer, respectively, with an ideal SCBF dosage of 0.5 percent..
2. Compressive strength of CCF and GPCF is increased by 12.35% and 13.15% compared to CC and GPC respectively.
3. Tensile strength of CCF and GPCF is increased by11.61% and 12.69% compared to CC and GPC respectively.
4. Flexural strength of CCF and GPCF is increased by 14.03% and 14.86% compared to CC and GPC respectively.
5. The compressive strength observed that it is increased up to 0.5% of fibre and further increase in dosage of SCBF, compressive strength is fallen.
6. Workability is decreased as the dosage of SCBF increased, but still it is in the required limit.

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