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# Experimental Investigation of M30 Grade Self Compaction Concrete by Partial Replacement of Bagasse Ash in Place of Cement and Glass Powder in Place of Fine Aggregate

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**Abstract:** *Self-compacting concrete (SCC), a recent innovation in concrete technology, has numerous advantages over conventional concrete. Self-compacting concrete, as the name indicates, is a type of concrete that does not require external or internal compaction, because it becomes leveled and consolidated under its self weight. SCC can spread and fill all corners of the formwork, purely by means of its self- weight, thus eliminating the need of vibration or any type of consolidating effort.*

*This report demonstrates the possibilities of using Bagasse ash and Glass powder as partial replacement of cement and fine aggregate in concrete. This experimental investigation was performed to evaluate the strength properties of concrete, in which the cement is partially replaced by Bagasse ash and fine aggregate was partial replaced with Glass powder. Cement was replaced by weight with five percentages (0%, 5%,10%, 15%, 20%) and fine aggregate was replaced with only one percentage (20%) of Glass powder by weight. Fresh properties of self-compacting concrete were studied. Compression test, splitting tensile strength and flexural strength test were carried out to evaluate the strength properties of concrete at the age of 7, 14, and 28 days.*

**Keywords:** *Bagasse ash, Glass powder, Self-compacting concrete, splitting tensile strength, Compressive strength, flexural strength.*

## I. INTRODUCTION

### A. General

Concrete is the man-made material which has the vast utilization worldwide. This fact leads to important problems regarding its design and preparation to finally obtain an economic cost of the product on short and longtime periods. The material has to be also “friendly with the environment” during its fabrication process and also its aesthetical

Appearance when it is used in the structures. Its success is when its raw materials that have a large spreading into the world, the prices of raw materials that are low and the properties and the performances of the concrete that confers it a large scale of application.

Concrete’s performances have continuously rise in order to accomplish the society needs. Many studies have been made concerning the use of additives and super-plasticizers in the concrete by using minimum water content for a good workability of a concrete. As a result of this, high performance concretes developed having a superior durability. Self-compacting concrete, as the name indicates, is a type of concrete that does not require external or internal vibration for placing and compaction but it gets compacted under its self-weight. It is able to flow under its own weight, completely filling formwork and achieving full compaction, even in the presence of congested reinforcement. At the same time it is cohesive enough to fill spaces of almost any size and shape without segregation or bleeding. This makes SCC particularly useful wherever placing is difficult, such as in heavily reinforced concrete members or in complicated formwork.

### B. Properties Of Self-Compacting Concrete

Fresh SCC must possess at required levels the following key properties related to workability:

- 1) *Filling Ability:* This is the ability of the SCC to flow, spread and fill into all spaces within the formwork under its own weight.
- 2) *Passing Ability:* This is the ability of the SCC to flow through tight openings such as spaces between steel reinforcing bars, under its own weight without blocking them.
- 3) *Resistance To Segregation:* The SCC must meet the required levels of properties and its composition remains uniform throughout the process of transport and placing that is keeps the sand and aggregate in suspension.

### C. Need For This Research

There are many situations in today's construction market that make SCC an interesting alternative to conventional slump concrete. In general, cost savings and/or performance enhancement tend to be the driving forces behind the added value of SCC. Contractors, producers and owners are under great pressure to produce better quality construction at lower costs of labour, materials and equipment. They are also faced with tougher environmental and safety regulations, and increased insurance costs. The economic benefits of a less intensive construction environment results in labour savings, time savings from higher productivity, and greater flexibility of design. SCC offers some help in all of the following areas. The main barrier to the increased use of SCC seems to be the lack of experience of the process, and the lack of published guidance, codes and specifications. This situation will improve, however, as experience and knowledge increases and each country begins to produce its own guidance and specifications for the production of SCC with local marginal aggregates and the harsh environmental conditions prevailing in the region. Therefore, there is a need to conduct studies on SCC. In this study, only 20% of Glass powder is used constant and Bagasse ash is partially replaced as the mineral admixture and an attempt is made to maximize the cementitious content in Self Compacting Concrete.

## II. LITERATURE REVIEW

### A. General

Self-compacting concrete (SCC), a recent innovation in concrete technology, has numerous advantages over conventional concrete. Self-compacting concrete, as the name indicates, is a type of concrete that does not require external or internal compaction, because it becomes levelled and consolidated under its self-weight. SCC can spread and fill all corners of the formwork, purely by means of its self-weight, thus eliminating the need of vibration or any type of consolidating effort. The notion behind developing SCC were the concerns regarding the homogeneity and consolidation of conventional cast-in-place concrete within intricate (that is, heavily-reinforced) structures and to improve the overall strength, durability, and quality of concrete. The SCC concrete is highly flowable and cohesive enough to be handled without segregation. It is also referred to as self-compacting concrete, super-workable concrete, highly flowable concrete, non-vibrating concrete, and other similar names.

Due to ever increasing quantities of waste materials and industrial by-products, solid waste management is the prime concern in the world. Scarcity of land-filling space, because of its ever increasing cost, recycling and utilization of industrial by-products and waste materials has become an attractive proposition to disposal. There are several types of industrial by-products and waste materials. The utilization of such materials in concrete not only makes it economical but also helps in reducing disposal concerns. Natural sand is getting depleted due to large scale construction. So it is important to find out an alternative of natural sand, which can be used as partial replacement of natural sand (fine aggregate). There are several types of waste material by products, which have been explored for possible use in concrete as a partial replacement of coarse aggregate. Such types of materials are coconut shells, recycled coarsed aggregate, sewage sludge ash, stone dust and glass cullet, and waste poly vinyl chloride chips, etc.

### B. Literature Survey

Ganesan et al., Studied the effects of SCBA content as partial replacement of cement (0-30%) on physical and mechanical properties of hardened concrete. The properties of concrete were investigated include compressive strength, splitting tensile strength, water absorption, permeability characteristics, chloride diffusion and resistance to chloride ion penetration. All tests carried out in accordance with Indian Standards. The test results indicated that SCBA is an effective mineral admixture up to 20% replacement was advantageous. The increase in strength may be partially due to the pozzolanic reaction.

Nunta chai et al., examined the importance of bagasse ash for development as pozzolanic materials in concrete. The physical properties of concrete containing ground bagasse ash (BA) including compressive strength, water permeability, and heat evolution were investigated and all tests were done in accordance with American Standards. When bagasse ash is ground up into small particles, the compressive strength of concrete containing this ground bagasse ash improves significantly. The low water permeability values of concretes containing ground bagasse ash at 90 days were mostly caused by the pozzolanic reaction. The higher the replacement fraction of Portland cement by ground bagasse ash, the longer the delay time to obtain the highest temperature rise. Concrete containing up to 30% ground bagasse ash had a higher compressive strength and a lower water permeability than the control concrete, both at ages of 28 and 90 days.

Kawade et al. studied the effect of use of SCBA on strength of concrete by partial replacement of cement at the ratio of 0%, 10%, 15%, 20%, 25% and 30% by weight for compressive strength. If some of raw material having similar composition can be replaced by weight of cement in concrete then cost could be reduced without affecting its quality. It was found that the cement could be



advantageously replaced with SCBA up to maximum limit of 15%. Partial replacement of cement by SCBA increases workability of fresh concrete; therefore use of super plasticizer is not essential. Tests were done in accordance with American Standards.

Srinivasan et al., studied chemical and physical characterization of SCBA, and partially replaced in the ratio of 0%, 5%, 15% and 25% by weight of cement in concrete. Compressive strength, split tensile strength, flexural strength and modulus of elasticity at the age of 7 and 28 days was obtained as per Indian Standards. It was found that the cement could be advantageously replaced with SCBA up to a maximum limit of 10%. Therefore it is possible to use sugarcane bagasse ash (SCBA) as cement replacement material to improve quality and reduce the cost of construction materials such as concrete.

Somna et al. studied the utilization of a pozzolanic material to improve the mechanical properties and durability of recycled aggregate concrete. Ground bagasse ash (GBA) was used to replace Portland cement at the percentages of 20, 35, and 50 by weight of binder. SCBA used to replace natural coarse aggregate not more than 25% by weight. When GBA was used to partially replace cement in recycled aggregate concrete, the chloride penetration decreased and was lower than those of control concrete at the same immersed time. Compressive strength, modulus of elasticity, water permeability, and chloride penetration depth of the concretes were determined as per American Standards. Recycled aggregate concrete by incorporating SCBA has the modulus of elasticity, lower than that of the conventional concrete by approximately 25–26%

Otuozu et al. concluded that SCBA was a good pozzolana for concrete cementation and partial blends of it with OPC could give good strength development and other engineering properties in concrete. An optimum of 10% SCBA with OPC could be used for reinforced concrete with dense aggregate. The replacement of cement by SCBA was 0-30% and in accordance with American and Brazilian Standards all tests were carried Out.

Lavanya et al. Examined the partial replacement for cement in conventional concrete. The tests were as per Bureau of Indian Standards (BIS), IS 516-1959 codes to evaluate the suitability of SCBA for partial replacements up to 30% of cement with varying water cement (w/c) ratio. The physical properties of SCBA were studied. Compressive strengths (7, 14 and 28 days) were determined in accordance with Indian Standards. The results showed that the addition of sugarcane bagasse ash improves the strengths in all cases. The maximum strength increase happens at 15% with 0.35 w/c ratio.

In this chapter we discuss the literature related to the use of Bagasse ash and glass powder in self-compacting concrete and other industrial by products as partial replacement of fine aggregates and partial replacement of cement in self-compacting concrete.

### III. EXPERIMENTAL PROGRAMME

#### A. General

The chapter describes the details of experimental programs for the measurements of fresh properties, strength properties (compressive strength, splitting tensile strength) of self-compacting concrete mixes made with varying percentages of Bagasse ash as partial replacement of cement along with the partial use of glass powder in place of fine aggregates. The basic tests carried out on concrete samples are discussed in this chapter, followed by a brief description about mix design and curing procedure adopted. At the end, the various tests conducted on the specimens are discussed.

#### B. Materials Used

1) *Cement*: Ordinary Portland Cement (OPC) Grade 53 JK cement was used for casting cubes and cylinders for all concrete mixes.

Table 3.1: Physical Properties of Ordinary Portland Cement

Physical Properties	BIS- 8112:1989	Test Result
Standard Consistency (%)		29.5
Setting time (min)		
Initial	30 Min.	92
Final	600 Max	248
Compressive Strength (MPa)		
3 day	29.15	28.85
7 day	46.22	48.21
28 day	53	57.84
Specific gravity	–	3.12

The cement was of uniform colour i.e. grey with a light greenish shade and was free from any hard lumps. It was tested as per Indian standard specification (BIS-8112:1989)

- 2) *Fine Aggregates*: The sand used for the experimental programme was locally procured and conformed to Indian Standard Specifications BIS: 383-1970. The sand was first sieved through 4.75 mm sieve to remove any particles greater than 4.75 mm. The aggregates were sieved through a set of sieves to obtain sieve analysis. Aggregates used were in dry state and correction for water absorption was made. The fine aggregate belonged to grading zone II. Its physical properties and sieve analysis are given in Tables 3.2 and Table 3.3 respectively.

Table 1.2: Physical Properties of Fine Aggregate

Characteristics	Value
Specific gravity	2.57
Bulk density	1.3
Fineness modulus	2.65
Water absorption	1.2
Grading Zone (Based on percentage passing 0.60 mm)	Zone II

- 3) *Coarse Aggregates*: The material which is retained on IS sieve no. 4.75 is termed as a coarse aggregate. The crushed stone is generally used as a coarse aggregate.. Locally available coarse aggregate having the maximum size of 10 mm was used. The aggregates used were dry condition and correction of absorption was taken. The aggregates were tested as per IS: 383-1970. Physical properties and sieve analysis results are given in Tables 3.4 and Table 3.5 respectively.

Table 3.3: Physical Properties of Coarse Aggregates (10mm)

Properties	Observed values
Colour	Grey
Maximum size (mm)	10
Specific Gravity	2.65
Total Water Absorption (%)	0.70
Moisture content(%)	Nil

#### 4) Mineral Admixtures

- a) *BAGASSE ASH*: Bagasse is the residue obtained from the bagasse in sugar producing factories . Bagasse is the cellular fibrous waste product after the extraction of sugarcane juice in industries. Generally the bagasse is used as bio-fuel, the ash produced in this process is about 3 tons for 10 tons sugarcane crush. The ash is rich in silica which imparts cementing properties increasing the workability and strength of Concrete. Bagasse Ash was burnt for approximately 72 hours in air in an uncontrolled burning process. The temperature was in the range of 700-1550<sup>0</sup>C. The ash collected was sieved through BIS standard sieve size 75µm and its colour was black. It was then measured by volume to replace the cement at 5%,10%,15% and 20%. Bagasse ash is taken from the nearing sugar mill factory. Specific gravity given by the manufacturer is about 1.84. Sugarcane Bagasse Ash was collected during the cleaning operation of a boiler operating in the Nava Bharat ventures Ltd.(sugar division) Sugar Factory, located in the city of Samalkot, Andhra pradesh. The chemical composition of bagasse ash is listed in below.

Table 3.4: Chemical Composition of The Bagasse Ash

S.No	Composition (% by mass)/property	Bagasse Ash
1	SiO <sub>2</sub>	78.34
2	Al <sub>2</sub> O <sub>3</sub>	8.55
3	Fe <sub>2</sub> O <sub>3</sub>	3.61
4	CaO	2.15
5	Na <sub>2</sub> O	0.12
6	K <sub>2</sub> O	3.46
7	MnO	0.13
8	TiO <sub>2</sub>	0.50
9	P <sub>2</sub> O <sub>5</sub>	1.07
10	Loss on ignition	0.42



Figure 3.1:70% of particle passing 0.090mm fine Bagasse ash particles

Table 3.5: Physical Properties of Bagasse Ash

S.No	Physical Properties	Test Value	Recommended Values
1	Specific gravity	2.45	----
2	Colour	Black	---
3	Bulk Density kg/m <sup>3</sup> Loose	396.5	----
	Compacted	462.32	
4	SiO <sub>2</sub> +Al <sub>2</sub> O <sub>3</sub> +Fe <sub>2</sub> O <sub>3</sub>	64.03	< 70% or < 60%
5	Loss of Ignition (LOI)	26.93	< 7%

b) *Glass Powder (GP)*: The chemical compositions of soda-lime glass which is the most commonly used in containers are compared with fly ash and cement as shown in Table 4. The chemical compositions of glass do not vary significantly irrespective of different origins. The SiO<sub>2</sub> and (Na<sub>2</sub>O + K<sub>2</sub>O) of glass are much higher than those of fly ash and cement. The total reactive component (SiO<sub>2</sub> + Al<sub>2</sub>O<sub>3</sub> + Fe<sub>2</sub>O<sub>3</sub>) contents of glass and fly ash are about the same. Other main constituent contents are in the similar range to those of fly ash and cement. Glass has a potential to be used as a powder in SCC. The preferred fineness of addition for SCC is more than 70% of particle passing 0.063mm fine glass powder was reported to contribute to Micro Structural Properties due to its filler effect pozzolanic reactivity the sulphate resistance/ penetration resistance and freeze /thaw of concrete was all improvement after incorporating 20-30% glass powder compare to those of bagasse ash. Glass powder was obtained from Anand cement agencies Kakinada. The powder product consisted of angular and flaky particle shapes.

The chemical composition and physical characteristics of Glass Powder used in the present investigation were given in Tables 3.6 and Table 3.7

Table 3.6: Chemical requirements of Glass Powder

S. No	Composition (% by mass)/property	Glass Powder
1	Silicon dioxide (SiO <sub>2</sub> )	70.22
2	Calcium oxide (CaO)	11.33
3	Magnesium Oxide (MgO)	---
4	Aluminum oxide (Al <sub>2</sub> O <sub>3</sub> )	1.64
5	Iron oxide (Fe <sub>2</sub> O <sub>3</sub> )	0.52
6	Total sulphur as sulphur Trioxide (SO <sub>3</sub> )	15.29
7	Potassium oxide (K <sub>2</sub> O)	---
8	Density	2.42
9	Specific Surface Area	133

Table 3.7: Physical requirements of Glass Powder

S.No	Physical properties	State of Nature/Value
1	Colour	White
2	Specific Gravity	2.15



Figure 3.2: 70% of particle passing 0.063mm fine Glass Powder.

- 5) *Chemical Admixture*: Auramix 400 of FOSROC brand is a high performance super plasticizer intended for applications where high water reduction and long workability retention are required, and it has been developed for use in Self Compacting concrete, Pumped concrete, Concrete requiring long workability retention ,High performance concrete. It is based on a polycarboxylic ether polymer with long lateral chains. This greatly improves cement dispersion. At the start of the mixing process an electrostatic dispersion occurs but the cement particle's capacity to separate and disperse. Its specific gravity is 1.11. This mechanism considerably reduces the water demand in flowable concrete. It combines the properties of water reduction and workability retention. It allows the production of high performance concrete and/or concrete with high workability. Specifications of super plasticizer are given in Table 3.8

Table 3.8: Specifications of Super plasticizer (Auramix)

Basis	Aqueous solution of modified polycarboxylate
Appearance	Light yellow coloured liquid
Volumetric mass	1.105 $\pm$ 0.02 kg/litre @ 20 <sup>0</sup> C
p <sup>H</sup>	Minimum 6
Chloride content	Nil to IS:456
Alkali content	less than 1.5 g Na <sub>2</sub> O equivalent / litre of admixture



Figure 3.3: Auromix super plasticizer

#### IV. RESULTS AND DISCUSSION

##### A. General

In this chapter, the findings of experimental investigations are presented. In which, various tests were conducted to evaluate the effect of Bagasse ash and Glass powder on compressive strength, splitting tensile strength, of concrete. Bagasse ash was used as a partial replacement of cement at the percentage of 0, 10, 15 and 20% and Constant percentage (20%) of partial replacement of Glass powder in fine aggregate. Design of different concrete mix and procedure of various tests are described in chapter 3.

##### B. Effect Of Bagasse Ash And Glass Powder On Scc

1) *Fresh Concrete Properties:* In order to study the effect on fresh concrete properties when Bagasse ash is used as a partial replacement of cement and Glass powder is used as a partial replacement of fine aggregate into the concrete ,SCC containing different proportion of Bagasse ash and Glass powder were tested for Slump flow, V-funnel, U-Box, L-box. The results of fresh properties of all Self-compacting concretes with Bagasse ash and Glass powder are included in Table 4.1. The table shows the properties such as slump flow, V-funnel flow times, L-box, U- box. In terms of slump flow, all SCCs exhibited satisfactory slump flows in the range of 550–800 mm, which is an indication of a good deformability.

Table 4.1: Fresh concrete properties

Mixture Id	Slump (mm)	V-funnel (SECONDS)	L-BOX H2/H1	U-box (H1- H2)
SCC (0%BA &0%GP )	605	7	1	5
SCC (5%BA &20%GP )	618	6.8	1	7
SCC (10%BA &20%GP )	627	6.6	0.9	11
SCC (15%BA &20%GP ))	639	6.28	1	17
SCC (20%BA &20%GP )	590	9.37	0.8	23

##### 2) Compressive Strength

a) *Effect Of Bagasse Ash And Glass Powder On Compressive Strength:* Effect of BA and GP on compressive strength of M30 Grade concrete mixes SCC-1(0%BA &0%GP), SCC-2 (5%BA &20%GP), SCC-3(10%BA &20%GP), SCC-4 (15%BA &20%GP) and SCC-5 (10%BA &20%GP), at the age of 7, 14 and 28days are shown in Fig. 4.6. Mix proportion of control concrete mix SCC-1 was 450 kg cement; 557.672 kg fine aggregate 139.418 kg of Glass powder and 1008 kg coarse aggregate per cubic meter of concrete with water-cement ratio 0.43. Compressive strength of control concrete mix was 37.13 MPa at the age of 28 days. It was found that, at the age of 7 days, compressive strength of mix SCC-1 (0%BA &0%GP) was 27.346 MPa and mixes SCC-2 (5%BA &20%GP), SCC-3 (10%BA &20%GP), SCC-4 (15%BA &20%GP) and SCC-5 (10%BA &20%GP) were 28.116, 32.506, 36.786 and 31.10 MPa, respectively. Maximum compressive strength (36.786 MPa) was observed for SCC-4 (15%BA &20%GP) concrete mix; it was 34.52 % more than the control mix SCC-1(0%BA &0%GP). At the age of 28 days, percentage increase in compressive strength was 14.66%, 23.54%, 46.143 % and 20.17% for mixes SCC-2, SCC-3, SCC-4 and SCC-5 than control mix SCC-1(37.13 MPa, it was observed that compressive strength of concrete increased with the increase in BA and GP content up to 15% as partial replacement of cement and 20% of fine aggregate.



Table 4.2: Compressive strength of concrete mixes with Bagasse ash and Glass powder

Mix	Compressive Strength (N/mm <sup>2</sup> )			Average Compressive Strength (N/mm <sup>2</sup> )		
	7 days	14days	28 days	7 days	14days	28 days
SCC-1 CM	27.36	30.20	36.95	27.34	31.61	37.13
	28.02	32.80	36.30			
	27.35	31.85	38.15			
	28.35	34.15	42.75			
SCC-2	28.05	34.26	41.95	28.11	34.57	42.57
	27.95	35.31	43.02			
	33.10	43.21	46.25			
SCC-3	31.78	41.49	45.59	32.50	42.35	45.87
	32.64	42.35	45.78			
	36.21	47.20	54.35			
SCC-4	37.35	46.35	53.24	36.78	46.58	54.26
	36.80	46.21	55.2			
	31.44	41.09	45.82			
SCC-5	29.20	40.01	44.76	31.10	40.06	44.62
	32.67	39.08	43.33			

Figure 4.1: Compressive strength of SCC Mixes of specimen size 150x150x150 with shows the variation of percentage increase in compressive strength with replacement percentage of bagasse ash and glass powder. The results also indicate that early age strength gain i.e. at 7 and 28 days, is higher when compared to the control mix if 15% of cement is replaced by bagasse ash and 20% fine aggregate is replaced by glass powder.

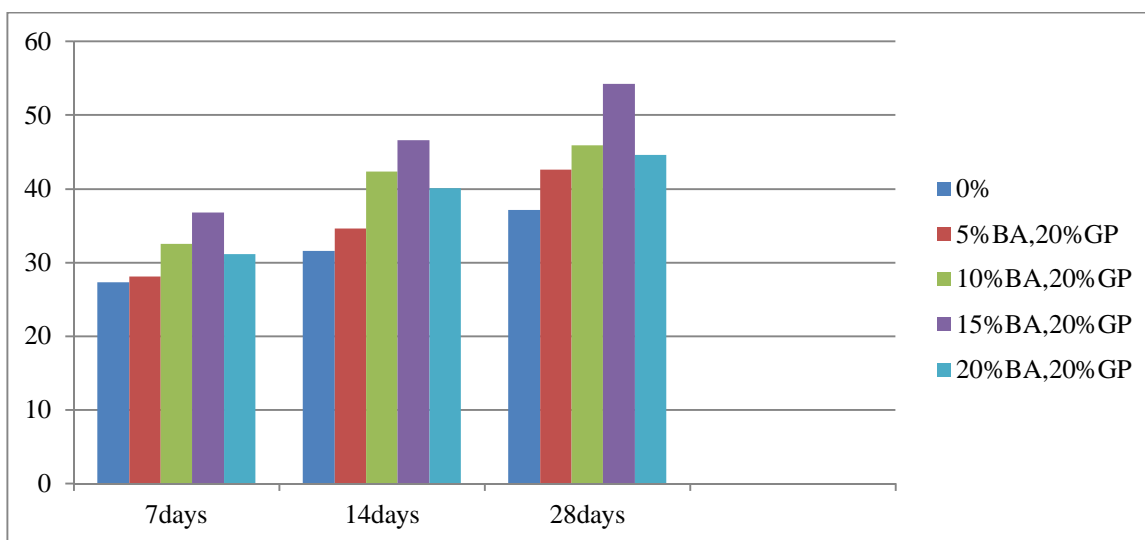


Figure 4.1: Compressive Strength Results

### 3) Split Tensile Strength

a) *Effect Of Bagasse Ash And Glass Powder On Split Tensile Strength:* Split tensile strength studies were carried out at the age of 7, 14 and 28 days. Test results are given below in Table 4.3. The variations in split tensile strength with Bagasse ash and Glass powder content were similar to that observed in case of compressive strength. Split tensile strength of concrete mixes increased with the increase in BA&GP content. Split tensile strength of control mix SCC-1(0%BA&0%GP) was 2.79 MPa at 7 days. It increased by 9.318%, 18.99%, 34.26% and 12.29% for SCC-2 (5%BA&20%GP), SCC-3 (10%BA&20%GP), SCC-4(15%BA&20%GP) and SCC-5 (20%BA&20%GP) respectively. Higher value of split tensile strength was observed at 15%

BA& 20%GP. At the age of 14 days, increase was 19.53%, 33.62%, 51.55% and 29.45% for SCC-2, SCC-3, SCC-4 and SCC-5 concrete mixes respectively than mix SCC-1 (3.123MPa). At 28 days, split tensile strength of mix SCC-1(0%BA&0%GP) was 3.746 MPa. Concrete mix SCC-2, SCC-3, SCC-4 and SCC-5 achieved an increase of 13.53%, 32.22%, 58.38% and 20.39%.. It was observed that up to 15%of bagasse ash and 20% of glass powder replacement cement and fine aggregate with, concrete mixture SCC-4 (15%BA&20%GP) showed higher value of split tensile strength among all mixes.

Table 4.3: Split tensile strength of concrete mixes with Bagasse ash and Glass powder

Mix	Split Tensile Strength (N/mm <sup>2</sup> )			Average Split Tensile Strength (N/mm <sup>2</sup> )		
	7 days	14days	28 days	7 days	14days	28 days
SCC-1 CM	2.56	3.15	3.70	2.79	3.12	3.74
	2.89	3.21	3.85			
	2.92	3.01	3.69			
SCC-2	3.05	3.50	4.21	3.05	3.73	4.25
	3.11	3.80	4.30			
	2.99	3.90	4.25			
SCC-3	3.23	4.12	4.73	3.32	4.17	4.95
	3.40	4.09	4.92			
	3.35	4.31	5.21			
SCC-4	3.67	4.50	5.70	3.74	4.73	5.93
	3.72	4.90	6.10			
	3.85	4.80	6.0			
SCC-5	3.11	3.90	4.41	3.13	4.04	4.51
	3.08	4.05	4.52			
	3.21	4.18	4.60			

Figure 4.2 shows the variation of split tensile strength with the percentage of Bagasse ash and Glass powder replaced. Figure 4.2 shows the variation of percentage increase in split tensile strength with replacement percentage of Bagasse ash and Glass powder. The strength gain at age of 5.933 and 28 days is highest for 15% Bagasse ash and 20% Glass powder replacement in cement and Fine aggregate respectively.

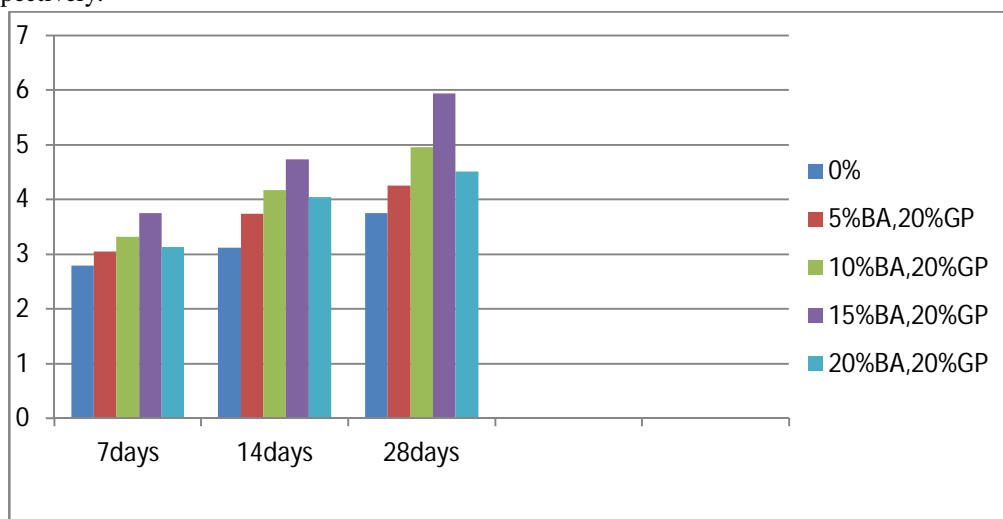


Figure 4.2: Split Tensile Strength Results

#### 4) Flexural Strength

a) *Effect Of Bagasse Ash And Glass Powder On Flexural Strength:* Flexural strength studies were carried out at the age of 7, 14 and 28 days. Test results are given below in Table 4.4. The variations in flexural strength with Bagasse ash and Glass powder

content were similar to that observed in case of compressive strength. Flexural strength of concrete mixes increased with the increase in BA&GP content. Flexural strength of control mix SCC-1(0%BA&0%GP) was 5.16 MPa at 7 days. It increased by 2.44%, 5.096%, 8.14% and 1% for SCC-2 (5%BA&20%GP), SCC-3 (10%BA&20%GP), SCC-4(15%BA&20%GP) and SCC-5 (20%BA&20%GP) respectively. Higher value of flexural strength was observed at 15% BA& 20%GP. At the age of 14 days, increase was 0.65%, 3.422%, 4.905% and 0.2% for SCC-2, SCC-3, SCC-4 and SCC-5 concrete mixes respectively than mix SCC-1 (7.216MPa). At 28 days, flexural strength of mix SCC-1(0%BA&0%GP) was 9.12 MPa. Concrete mix SCC-2, SCC-3, SCC-4 and SCC-5 achieved an increase of 2.302%, 4.715%, 5.921% and 0.8%.. It was observed that up to 15% of bagasse ash and 20% of glass powder replacement cement and fine aggregate with, concrete mixture SCC-4 (15%BA&20%GP) showed higher value of flexural strength among all mixes. Table 4.4 shows the details of the flexural strength of M30 grade of SCC.

Table 4.4: Flexural strength of concrete mixes with Bagasse ash and Glass powder

Mix	Flexural Strength (N/mm <sup>2</sup> )			Average Flexural Strength (N/mm <sup>2</sup> )		
	7 days	14days	28 days	7 days	14days	28 days
SCC-1 CM	5.13	7.25	9.2	5.16	7.216	9.12
	5.20	7.18	9.05			
	5.15	7.22	9.11			
SCC-2	5.16	7.26	9.35	5.12	7.263	9.33
	5.10	7.28	9.4			
	5.12	7.25	9.24			
SCC-3	5.13	7.41	9.48	5.15	7.463	9.55
	5.08	7.5	9.62			
	5.24	7.48	9.55			
SCC-4	5.15	7.52	9.7	5.19	7.57	9.66
	5.20	7.59	9.65			
	5.22	7.61	9.64			
SCC-5	4.72	7.24	9.22	4.69	7.23	9.2
	4.69	7.31	9.18			
	4.66	7.14	9.2			

Figure 4.3 shows the variation of flexural strength with the percentage of Bagasse ash and Glass powder replaced. Figure 4.3 shows the variation of percentage increase in flexural strength with replacement percentage of Bagasse ash and Glass powder. The strength gain at age of 4.56 and 28 days is highest for 15% Bagasse ash and 20% Glass powder replacement in cement and Fine aggregate respectively.

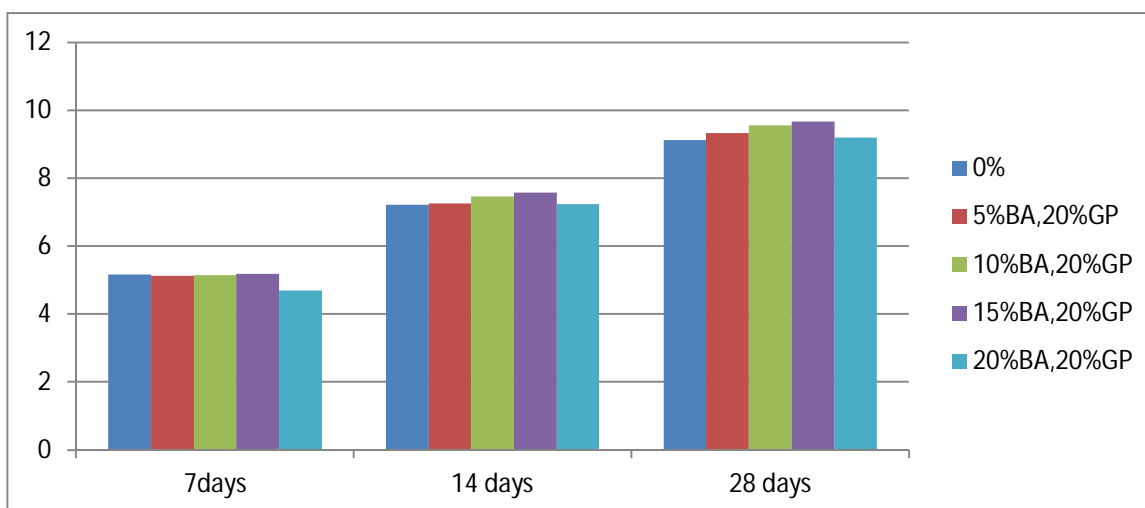


Figure 4.3: Flexural Strength Results

## V. CONCLUSIONS

### A. General

The present work investigated the influence of bagasse ash and glass powder as partial replacement of cement and fine aggregate (sand) on the properties self-compacting concrete. On the basis of the results from the present study, following conclusions are drawn.

### B. Strength properties

#### 1) Compressive Strength

- Compressive strength of concrete mixes increased due to partial replacement of fine aggregate with glass powder and partial replacement of cement with bagasse ash. However, compressive strength observed was appropriate for structural uses.
- M30 (37.13MPa) grade concrete mix obtained increase in 28-day compressive strength from 37.12MPa to 54.263MPa on 15% replacement of cement with Bagasse ash and 20% replacement fine aggregate with Glass powder. Maximum strength was achieved with 15% replacement of cement with Bagasse ash and 20% replacement fine aggregate with Glass powder. Beyond 15% replacement of cement with Bagasse ash and 20% replacement fine aggregate with Glass powder it goes to decrease, but was still higher than control concretes.
- Compressive strength also increased with increase in age of concrete. The rate of compressive development of bagasse ash and Glass powder concrete mixes were higher compared to no bagasse ash and Glass powder concrete mixes.

#### 2) Split Tensile Strength

- Concrete mixes obtained linear increase in 28-day split tensile strength from 3.746 MPa to 5.933MPa for concrete mix on replacement of fine aggregate with bagasse ash at various percentages of 0% to 20% and Glass powder is maintaining a constant percentage of replacement, i.e., 20%.
- Split tensile strength of all concrete mixes was found to increase with increase in with varying percentage of bagasse ash and constant replacement of Glass powder.
- Maximum increase in split tensile strength was observed at 15% replacement of cement with Bagasse ash and 20% replacement of fine aggregate with Glass powder at all age for concrete mixes.

#### 3) Flexural Strength

- Concrete mixes obtained linear increase in 28-day strength from 9.12MPa to 9.66MPa for concrete mix on replacement of fine aggregate with bagasse ash at various percentages of 0% to 20% and Glass powder is maintaining a constant percentage of replacement, i.e., 20%.
- Flexural strength of all concrete mixes was found to increase with increase in with varying percentage of bagasse ash and constant replacement of Glass powder.
- Maximum increase in flexural strength was observed at 15% replacement of cement with Bagasse ash and 20% replacement of fine aggregate with Glass powder at all age for concrete mixes.

### C. Scope For Futher Work

From this experimental study it is clear indicated that using sugar cane bagasse ash in concrete increase strength.

Following parameters will be study in future work:

- The simplified mix design methodology was presented may be extended to the more number of concrete strength ranges.
- The investigations may be conducted with different mineral admixtures like Rice Husk Ash, palm oil ash and GGBS apart from Bagasse ash.
- To find out optimum amount of different types of mineral admixtures like Rice Husk Ash, palm oil Ash, and GGBS that can be used in concrete for partially replacement of cement without significant loss of strength.
- To check the various properties of concrete with variation of content of different types of mineral admixtures like Rice Husk Ash, palm oil Ash, and GGBS.

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