An Experimental Investigation on Strength Properties of Self Compaction Concrete with Partial Replacement of Cement with Bagasse Ash and Glass Powder as Fine Aggregate

[#1] Guttala Mahalakshmi, [#2] M.S.G Priyanka, [#3] S.Sravanthi

[#1] PG Student, Department of Civil Engineering, B V C Engineering College(Autonomous), Odalarevu.
[#2] Assistant Professor , Department of Civil Engineering, B V C Engineering College (Autonomous), Odalarevu.
[#3] Assistant Professor , Department of Civil Engineering, B V C Engineering College (Autonomous), Odalarevu.

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 form work, purely by means of its self- weight, thus eliminating the need of vibration or any type of consolidating effort. In this present investigation the workability and strength properties of self compacting concrete with bagasse ash and glasspowder in different properties of 5%, 10%, 15 %, 20%. The workability parameters of M30 grade concrete using slump cone test and and compaction parameters of M30 grade of self compacting concrete using compressive strength test flexural strength test and split tensile strength for strength parameters, each grade of concrete for each proportion, cubes , beams and cylinders are to be cast for 7 days, 14 days and 28 days.

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

Introduction:

- Concrete is a widely used construction material around the world, and its properties have been undergoing changes through technological advancement. Numerous types of concrete have been developed to enhance the different properties of concrete.
- The earliest is the traditional normal strength concrete which is composed of only four constituent materials, which are cement, water, fine and coarse aggregates.
- With a fast population growth and a higher demand for housing and infrastructure, accompanied by recent developments in Civil Engineering, such as high-rise buildings and long-span bridges, higher compressive strength concrete was needed.
- At the beginning, reducing the water-cement ratio was the easiest way to achieve the high compressive strength. Thereafter, the fifth ingredient, a water reducing agent or super plasticizer was indispensable. The chemical admixture is said to be any material that is added in a small quantity (i.e., less than 5%) to the concrete mixture which enhances the properties of concrete in both the fresh and hardened state.

Importance Of Scc:

- Increases the powder content, ensures cohesiveness or viscosity of the mixture and reduces coarse aggregate.
- A substitution part of cement that is Bagasse ash is used for achieving economy.
- The required flow ability is achieved with the help of super plasticizers which is able to retain its dispersing effect for at list two hours.
- Stabilizing agent (viscosity modifying agent) is usually needed through that small changes in water concrete of mixes, which arise due to site variables, do not adversely affect the cohesiveness of SCC
- SCC has proved beneficial is Faster construction, Reduction in site manpower, Better surface finishing, Improve durability, Easier placing, Greater freedom in design, Reduce noise levels, absence of vibration

Mechanism For Achieving Self-Compatibility

- Simply increasing the water content in a mix to achieve a flow able concrete like SCC is obviously not a viable option. Instead, the challenge is to increase the flow ability of the particle suspension and at the same time avoid segregation of the phases

- The main mechanism controlling the balance between higher flow ability and stability are related to surface chemistry
- The development of SCC has thus been strongly dependent on surface active admixtures as well as on the increased specific surface area obtained through the used fillers.
- The method for achieving Self-Compatibility involves not only high deformability of Bagasse ash paste or mortar but also resistance to segregation between coarse aggregate and mortar when the concrete flows through the confined zone of reinforcing bars.

Objective:

- To mention a range of results, for the chosen tests, which will enable non specialists to identify suitable SCC, and be considered for compliance in specifications.
- To confirm the scientific basis of these tests by fundamental rheological measurements of the concrete.
- To encourage the use of self-compaction concrete in general construction and to realize the potential and economical and environmental benefits of this technology.
- To arrive at an appropriate mix design for self-compaction concrete and analyze their rheological properties.
- To study the effect of glass powder on the durability parameters of SCC using Bagasse ash.
- To investigate the effect of dosages of blended admixture on compressive strength, split tensile strength and flexural strength of self-compaction concrete.

Components of scc Coarse aggregate:

The coarse aggregate chosen for Self Compaction Concrete should be well graded and smaller in terms of the maximum size than that used for conventionally vibrated concrete (20mm or even more in general).

Fine Aggregate:

Siliceous and calcareous sands can be used for production of SCC. The amount of fines less than 0.125mm is to be considered as powder which is very important for the theology of SCC.

Cement:

All types of cements conforming to Bureau of Indian standards are suitable as per Indian conditions. Selection of the type of the cement is made depending on the overall requirements of SCC such as strength, durability etc.

Water:

Potable water shall be used for the production of SCC. In case of conventional concretes the water is proportionate only with the cement content. It is called as the water-cement ratio.

Mineral Admixtures:

Mineral admixtures are added to concrete as a part of the cementations material. They may be used as an addition to or as a part replacement of Portland cement in concrete.

Bagasse Ash:

Bagasse Ash was burnt for approximately 72 hours in air in an uncontrolled burning process. The temperature was in the range of 700-15500C.The ash collected was sieved through BIS standard sieve size 75µm and its colour was black.

Glass Powder:

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.

Chemical Admixtures:

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.

EXPERIMENTAL WORK

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-

15500C.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 venturs Ltd.(sugar division) Sugar Factory, located in the city of Samalkot, Andhra pradesh.

Chemical Composition of Bagasse Ash

S.No	Composition (% by mass)/property	Bagasse Ash
1	SiO2	78.34
2	Al2O3	8.55
3	Fe2O3	3.61
4	CaO	2.15
5	Na2O	0.12
6	K2O	3.46
7	MnO	0.13
8	TiO2	0.50
9	P2O5	1.07
10	Loss on ignition	0.42

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/m3**		
	Loose	396.5	
	Compacted	462.32	
4	SiO2+Al2O3+Fe2O3	64.03	< 70% or < 60%
5	Loss of Ignition (LOI)	26.93	< 7%

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 SiO2 and (Na2O + K2O) of glass are much higher than those of bagasse ash and cement. The total reactive component (SiO2 + Al2O3 + Fe2O3) contents of glass and bagasse ash are about the same. Other main constituent contents are in the similar range to those of bagasse 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.

chemical requirements of glass powder

S.No	Chemical Constituents	Percentage
1	Silicon dioxide(SiO2)	70.22
2	Calcium oxide (CaO)	11.33
3	Magnesium Oxide (MgO)	---
4	Aluminum oxide(Al2O3)	1.64
5	Iron oxide (Fe2O3)	0.52
6	Total sulphur as sulphur trioxide(SO3)	15.29
7	Potassium oxide (K2O)	---
8	Density	2.42
9	Specific Surface Area	133

.Physical Properties of Glass Powder

S.No	Physical properties	Percentage
1	Colour	white
2	Specific Gravity	2.15

Cement:
Selection of the type of cement will depend on the overall requirements for the concrete, such as strength, durability, etc. content higher than 10% may cause problems of poor workability retention.
The physical characteristics of Ultra-Tech (53 Grade)cement used, tested in accordance with IS:4031-1988 [Methods of physical tests for hydraulic cement].
The typical content of cement is 350-450 Kg/m3.

More than 500 Kg/m3 cement can be dangerous and increase the shrinkage.

Less than 350 Kg/m3 May only is suitable with the inclusion of other fine filler, such as fly ash, pozzolana, glass powder etc

S. No	Property	Test Method	Test Results	IS Standard
1.	Normal Consistency	Vicat Apparatus(IS:4031 Part-4)	29.5 %	
2.	Specific Gravity	Sp. Gr Bottle (IS:4031 Part-4)	3.10	
3.	Initial Setting Time	Vicat Apparatus (IS:4031 Part-4)	53 minutes	Not less than 30 minutes
	Final Setting Time		493 Minutes	Not less than 10 hours
4.	Fineness	Sieve test on sieve no.9 (IS: 4031 Part -1)	5%	10%
5.	Soundness	LeChatlier method (IS: 4031 Part-3)	2mm	Not more than 10mm

Super Plasticizer :

High range water reducing admixture called as super plasticizers are used for improving the flow or workability for lower water-cement ratios without sacrifice in the compressive strength.

These admixtures when they disperse in cement agglomerates significantly decrease the viscosity of the paste by forming a thin film around the cement particles.

In the present work, the admixture used was a super plasticizer based on modified polycarboxylates, with a density of 1.08 kg/l and a solids content of 32.5%.

It was used to provide necessary workability. The physical characteristics of Super Plasticizer used in the present investigation.

Specifications of Super plasticizer (Auramix)

Basis	**Aqueous solution of modified poly carboxylate**
Appearance	Light yellow coloured liquid
Volumetric mass	1.105 ± 0.02 kg/litre @ 200C
PH	Minimum 6
Chloride content	Nil to IS:456
Alkali content	less than 1.5 g Na2O equivalent / litre of admixture

mix proportion of self-compacting concrete

Type of Cement	**O.P.C(53Grade)**
Specific gravity of cement	3.12
Specific gravity of coarse aggregate	2.65
Specific gravity of fine aggregate	2.57
Specific gravity of Admixture	1.11

Adjustment Table for % of volume of water and FA

Material	**Water Absorption**	**Free Moisture**	**Total Correction**
Coarse aggregate 10mm	0.7%	0%	0%
Fine aggregate river sand	1.2%	0%	1.2%

Ingredients in SSD condition

Ingredient	**Kg/m3**
Cement	450
Total Cementetious	450
Total Water content	210.67
Fine Aggregate	697.09
Coarse Aggregate(10 and 20 mm)	1008.9
Admixture	3.6

Mix Proportions

Mix ID	**cement Kg/m3**	**Bagassе ash Kg/m3**	**Glass powder Kg/m3**	**F.A Kg/m3**	**C.A Kg/m3**	**Water Kg/m3**	**S.P Kg/m3**	**S.P %**
CM	450	0	139.41	557.	1008	210.67	3.6	0.

			8	672	.96			8
5% BA	427.5	22.5	139.418	557.672	1008.96	210.67	3.6	0.8
10% BA	405	45	139.418	557.672	1008.96	210.67	3.6	0.8
15% BA	382.5	67.5	139.418	557.672	1008.96	210.67	3.6	0.8
20% BA	360	90	139.418	557.672	1008.96	210.67	3.6	0.8

Test Conducted For Scc:

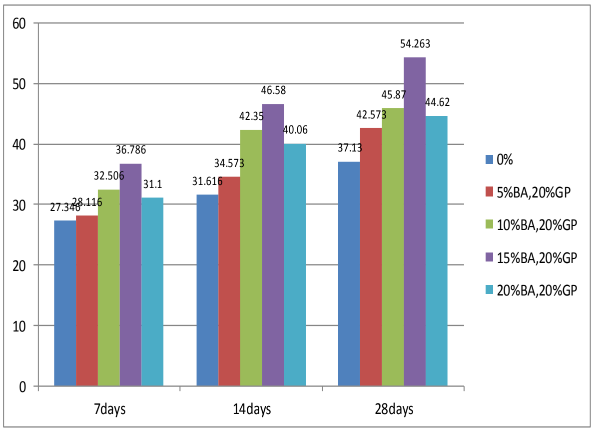
1. Slump flow test and T50 cm test
2. L - Box test
3. V - funnel test and V - funnel test at T5 minutes
4. U - Box test

Tests On Hardened Concrete

Compressive Strength :

Compressive strength of a material is defined as the value of uniaxial compressive stress reached when the material fails completely.

Mix	Compressive Strength (N/mm2)			Average Compressive Strength (N/mm2)		
	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			
SCC-2	28.35	34.15	42.75	28.11	34.57	42.57
	28.05	34.26	41.95			
	27.95	35.31	43.02			
SCC-3	33.10	43.21	46.25	32.50	42.35	45.87
	31.78	41.49	45.59			
	32.64	42.35	45.78			
SCC-4	36.21	47.20	54.35	36.78	46.58	54.26
	37.35	46.35	53.24			
	36.80	46.21	55.2			
SCC-5	31.44	41.09	45.82	31.10	40.06	44.62
	29.20	40.01	44.76			
	32.67	39.08	43.33			

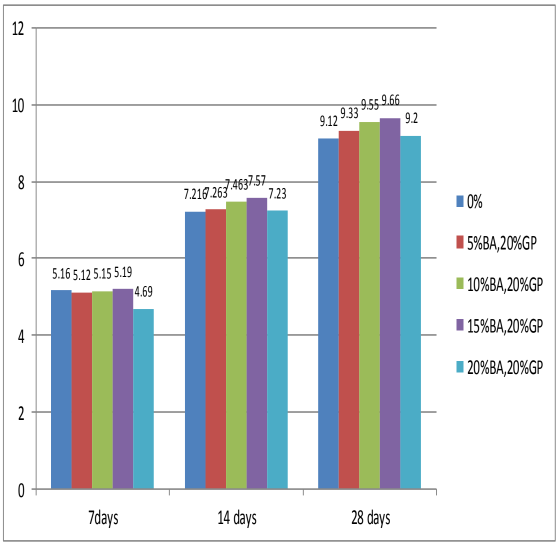


Flexural Strength :

Standard beam test (Modulus of rupture) was carried out on the beams of size 100 mm x 100 mm x 500 mm as per IS: 516 [Method of test for strength of concrete], by considering that material is homogeneous.

Mix	Flexural Strength (N/mm2)			Average Flexural Strength (N/mm2)		
SCC-1 C	**7 days**	**14days**	**28 days**	**7 days**	**14days**	**28 days**
	5.13	7.25	9.2	5.16	7.216	9.12

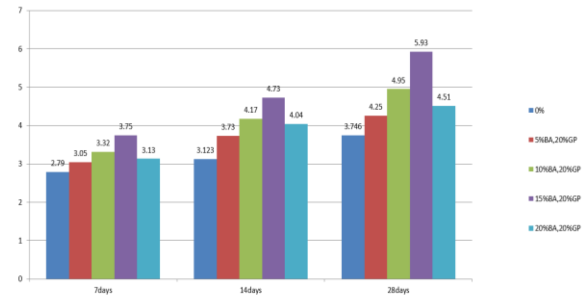
M	5.20	7.18	9.05			
	5.15	7.22	9.11			
SC C-2	5.16	7.26	9.35	5.12	7.263	9.33
	5.10	7.28	9.4			
	5.12	7.25	9.24			
SC C-3	5.13	7. 41	9.48	5.15	7.463	9.55
	5.08	7.5	9.62			
	5.24	7.48	9.55			
SC C-4	5.15	7.52	9.7	5.19	7.57	9.66
	5.20	7.59	9.65			
	5.22	7.61	9.64			
SC C-5	4.72	7.24	9.22	4.69	7.23	9.2
	4.69	7.31	9.18			
	4.66	7.14	9.2			



Split tensile strength :

The test was carried out by placing a cylindrical specimen horizontally between the loading faces of a compression testing machine and the load was applied until failure of the cylinder, along the vertical diameter.

Mix	**Split Tensile Strength (N/mm2)**			**Average Split Tensile Strength (N/mm2)**		
SC C-1 CM	7 days	14days	28 days	7 days	14days	28 days
	2.56	3.15	3.70	2.79	3.12	3.74
	2.89	3.21	3.85			
	2.92	3.01	3.69			
SC C-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			
SC C-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			
SC C-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			
SC C-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			



Conclusions

COMPRESSIVE STRENGTH

1. 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.
2. 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.
3. 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

Flexural Strength

1. 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%.
2. 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.
3. 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.

Split Tensile Strength

1. 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%.
2. 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.
3. 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.

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:

1. The simplified mix design methodology was presented may be extended to the more number of concrete strength ranges.
2. The investigations may be conducted with different mineral admixtures like Rice Husk Ash, palm oil ash and GGBS apart from Bagasse ash.
3. 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.
4. 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.

References

[1] Paya J et. al, Sugarcane bagasse ash (SCBA): studies on its properties for reusing in concrete production, Journal of Chemical technology and Biotechnology, (2002)77, 321-325.

[2] R.Srinivasan and K.Sathiya"Experimental Study on Bagasse Ash in Concrete" International Journal for Service Learning in Engineering Vol. 5, No. 2, pp. 6066, Fall 2010.

[3] Vinicius N. Castaldelli et. al., "Use of Slag/Sugar Cane Bagasse Ash (SCBA) Blends in the Production of Alkali-Activated Material", Materials 2013, 6, pp. 3108-3127.

[4] EFNARC. "Specification and guidelines for self-compacting concrete", European Federation of Producers and Applicators of Specialist Products for Structures, 2002.

[5] EFNARC. "Specification and guidelines for self-compacting concrete", European Federation of Producers and Applicators of Specialist Products for Structures, May 2005.

[6] Jaya Shankar R, Hemalatha T, Palanichamy. K and Santhakumar. S, "Influence of fly ash and VMA on properties of self-compacting concrete", National Conference on Advances in materials and mechanics of concrete structures Department of Civil Engineering, IIT Madras, Chennai 12-13 August 2005, pp 25 - 32.

[7] Nan Su, Kung-Chung Hsub and His-Wan Chai. "A simple mix design method for self-compacting concrete". Cement and Concrete Research, 2001, Vol. 31, pp1799.

[8] Okamura H, Ozawa K. "Mix design for self-compacting concrete".concrete Library of Japanese Society of Civil Engineers, 1995, Vol. 25, No. 6, pp10 120.

[9] Okamura Hajime and Ouchi Masahiro. "Self - Compacting Concrete". Journal of advanced concrete technology, 2003, Vol.1, No.1, pp 5

-15.

[10] Subramanian, S. and Chattopadhyay D. “Experiments for mix proportioning of self-compacting concrete”, The Indian Concrete Journal, 2002, pp.13-20.

[11] List of Referred Standard Codes

1. IS: 456 - 2000 Code of practice for plain and reinforced concrete (fourth revision).
2. IS: 516 - 1959 Method of test for strength of concrete (sixth print January, 1976).
3. IS: 12269-1987 Specifications for 53 Grade Ordinary Portland cement.
4. IS: 383- 1970 Specification for Coarse and fine aggregates from natural sources

[12] for concrete.

[13] IS: 2386 - 1963 (all parts) Methods of test for aggregate for concrete.

[14] 6. IS: 3812 - 1981 Specifications for fly - ash for use as pozzolana and admixture (first revision).

[15] 7. IS: 3812 - 2003 Specifications for Fly Ash for use as pozzolona and admixture.

[16] IS: 1727 - 1967 Methods of test for pozzolana materials (first revision,reprinted

[17] January, 1989).

[18] IS: 9103 - 1999 Specification for admixtures for concrete (first revision).

[19] IS: 1199 - 1959 Methods of sampling and analysis of concrete.