Experimental Studies On Self Compacting Geopolymer Concrete Containing Ggbs-Bottom Ash

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Abstract— *Selfcompacting concrete (SCC) represents one of the most outstanding advances in concrete technology. Self-compacting concrete is a flowing concrete mixture that is able to consolidate under its own weight. The highly fluid nature of SCC makes its suitable for placing in difficult situation and in sections with congested reinforcement. In this paper experimental studies are carried out to understand the fresh and hardened properties of Self Compacting Concrete (SCC) in which cement is replaced by Ground Granulated Blast Furnace Slag (GGBS) and Bottom Ash (BA) (i.e. Geo polymer concrete) in various proportions. The workability properties such as filling ability, passing ability and resistance to segregation were assessed using slump flow, T-50cm slump flow, V-funnel, L-Box and J-ring test methods. It was found that the essential workability requirements for self-compact ability according to EFNARC were satisfied. The proportions of GGBS: BA in which cement replaced is 100:0, 75:25, 50:50, 25:75 and 0:100. The alkaline liquid used in geo polymerization was the combination of sodium hydroxide (NaOH) and sodium silicate (Na2SiO3) was 2.The Molarity of NaOH was considered as 8M. Super plasticizer GLENIUM B233 is used to maintain workability with constant Water-Binder ratio. From the test result it was observed that compressive strength was achieved at early ages under ambient curing was selected.*

Keywords— Geopolymer concrete, Self-compacting concrete (SCC), Granulated Blast Furnace Slag (GGBS), Bottom ash, Alkaline liquid (NaOH,Na2SiO3), compressive strength, split tensile strength, flexural strength and modulus of elasticity.

1. INTRODUCTION

In the developing world, the concrete is one of the important material to construct the structure. Due to the excess usage of cement for concrete work leads to the release of excess carbon-dioxide into the atmosphere. To overcome this problem many researchers introduced the concept of geopolymer concrete. In this aspect, GPC is one of the revolutionary development as an alternative to Portland cement.SCGC (Self Compacting Geopolymer Concrete) is one of the most innovative development in concrete technology. SCGC does not need any additional compaction. Hence this SCGC is more suitable in congested areas. An attempt has been made to investigate the experimental study on self-compacting geopolymer concrete. This process was analyzed by fresh and hardened concrete of SCGC with different mix proportions. The fresh concrete of workability test on slump flow, T50cm slump flow, L-box, J-ring, V-funnel test and hardened property are compressive strength, split tensile strength and flexural strength was evaluated.

2. OBJECTIVE OF THE PROJECT:

- **Arrive the suitable mix proportion** for the SCGC with GGBS and BOTTOM ASH.
- **To study the fresh concrete workability** properties of SCGC.
- **To study the mechanical properties** such as compressive strength, split tensile strength and flexural strength.
- **To evaluate the pozzalonic materials** such as bottom ash, GGBS and their effect in SCGC.

3. SCOPE OF THE STUDY:

- To reduce the CO_2 level in atmosphere by alternative OPC and use of other pozzalonic materials to neglect OPC in concrete.Compaction of concrete is the important process to make the concrete to achieve desired strength. The conventional compaction methods requires more labour time and also may not be effective in compacting in congested reinforcement area.Hence, an attempt is to be made the pozzalonic materials such as bottom ash and GGBS. Where used to achieve self compacting property in geo polymer concrete.

4. LITERATURE REVIEW:

- **Ganesh Babu & Nandhini (2017) "Strength and Durability Characteristics of Self compacting Geo polymer Concrete", Vol 4, No. 3, pp.21-24.**This project report is an attempt to find out suitable utilization of fly ash by assembling the SCGC, by studying the compressive strength of SCGC and to observe some durability characteristics of Self- Compacting Geopolymer Concrete . The increase in superplasticizer dosage the workability is increased. Superplasticizer dosage of up to 5% was found insufficient to produce desired flowability. The compressive strength of Self Compacting Geo-polymer concrete is higher in 11M concentration of NaOH solution. The strength characteristic of geo-polymer concrete depends on the molar concentration of sodium hydroxide (NaOH).

- **Rashida et.al (2013) "Experimental Investigation On Self-compacting Geo polymer Concrete", Vol 3 , No.4 ,pp.173-175.**The study were to assess the performances of self-compacting geopolymer concrete under the normal cured concrete and high temperature cured concrete. The investigation of flyash based self-compacting geopolymer concrete is made due to their relatively lower cost and simple synthesis procedures. This project report is an attempt to find out suitable utilization of fly ash by assembly the SCGC. By studying the compressive strength of SCGC and to observe the some durability characteristics of self-compacting Geopolymer concrete. therefore effect of SCGC on adverse conditions are used to test its durability namely, carbonation permeability, acid attack, water absorption. It is observed that maximum compressive strength of self-compacting geopolymer concrete is achieved at elevated temperature cured concrete.

- **Ashraf Mohamed Henigal et.al (2017) "Study On Properties Of Self-compacting Geo polymer Concrete" Vol no 14, no 2, (pp 52-66).**This paper study of the fresh states ,mechanical and physical properties for self-compacting geopolymer concrete SCGC by utilizing locally available constituents materials. This paper study of the fresh and mechanical properties for self-compacting geopolymer concrete, In addition to the physical properties. The mechanical properties of self-compacting geopolymer concrete are only a fraction of the compressive strength, as in the case of self-compacting concrete (SCC) with Portland cement. Increasing in the test results of physical properties adversely affect it's the mechanical properties of self-compacting geopolymer concrete. Increasing in the test results of physical properties adversely affect it's the mechanical properties of self-compacting geopolymer concrete. Heat-cured SCGC undergoes very low drying shrinkage compared to that of SCC with ordinary Portland cement. The permeability and water absorption of the hardened SCGC decrease with the increase in compressive strength of the SCGC.

- **Elavenil (2017) "Geopolymer Concrete With Self Compacting: A Review" vol .8, No. 2, P(163–172).**The Fly ash based SCGC was got high compressive strength in heat curing as well as low compressive strength in ambient curing. The presence of GGBS improves the strength in ambient curing. For aiming the high strength in ambient curing Fly ash will be completely replace. GGBS at ambient curing condition had more compressive strength rather than Fly ash based SCGC. The specimens were cured at 70^{o}C had produced higher compressive strength.The FESEM described that the concrete performance was improved, when its thickness was decreased and the

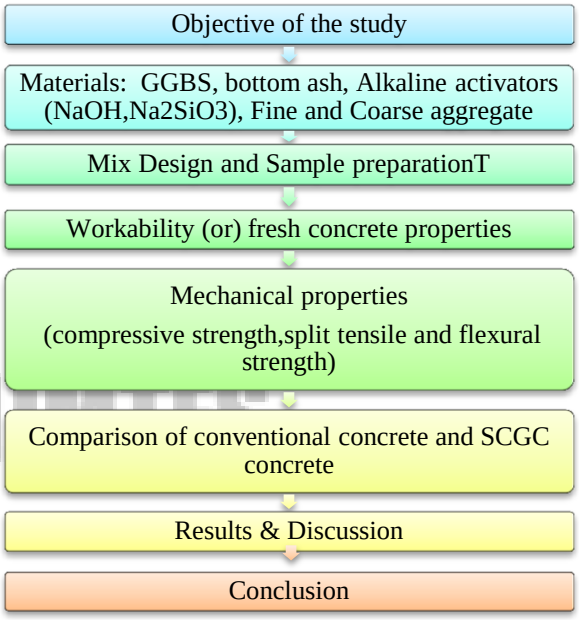
compressive strength was increased at higher SP dosage of 7%.

- **Kasireddy Malli karjuna Reddy & Nagesh Kumar (2017) "Experimental Study on Self Compacting Geo polymer Concrete" Vol.04,no. 01,pp (953-957).**The results showed that the addition of GGBS to flyash based SCGC, the workability characteristics are decreased and strength was increased with increase in binder content. Hence the results showed that the SCGC was suitable for both oven & ambient temperature curing with GGBS as replacement to flyash based GPC. By adding GGBS to flyash based SCGC, the strength properties are increased. Ambient temperature curing for 28 days specimens has high strength compare to oven cured specimens at 70^0C for 7 days. Economic benefits are achieved by reducing cost curing and labour for compaction. The SCGC is suitably designed for both oven curing at 70^0C and ambient temperature curing.

- **Natarajan et.al "Strength Economic and Sustainability Characteristics Of Coal Ash –GGBS Based Geo polymer Concrete" Vol.3,no.5, pp(163-171).**The effect of curing methodology on strength of fly ash-GGBS based geo polymer concrete has also been evaluated. Economic impact and sustainability studies were conducted on both OPC based concrete and geo polymer concrete.Bottom ash –GGBS based geo polymer concrete gives very low strength probably due to large particle size. The embodied energy of fly ash- GGBS based geo polymer concrete is 40 % less than that of OPC based concrete.

- **Rounak Hussain (2015) "A Study on Properties of Bottom Ash-GGBS Geo polymer Concrete For Paver Blocks" Vol.4, no.4,pp(52-66).**The study bottom ash and GGBS based geopolymer was used as the source material to produce geopolymer concrete for paver blocks. The alkaline liquid used in geopolymerisation was the combination of sodium hydroxide (NaOH) and sodium silicate (Na_2SiO_3) In the source material 75% BA and 25% GGBS was selected. From the test result it was observed that compressive strength of M30 and M35 grade was achieved at early ages under ambient curing.The test result it was observed that compressive strength of M30 and M35 grade was achieved at early ages under ambient curing.

5. WORK METHODOLOGY:



6. MATERIALS USED:

Ggbs & BOTTOM ASH ,NAOH & NA2SIO3 ,FINE AGGREGATE,COARSE AGGREGATE,SUPER PLASTICIZER (GLENIUM SKY 8233 POLY CARBOXYLIC-ETHER),RETARDERS (SUCROSE).

7. MIX DESIGN FOR SCGC:

- Mix ratio = 1 : 1.15 : 1.10
- Binder materials = GGBS : B.A
- GGBS : B.A = 100:0%, 75:25%, 50:50% , 25:75% , 100:0%
- Sand = River sand
- Coarse aggregate = 12 mm size aggregate

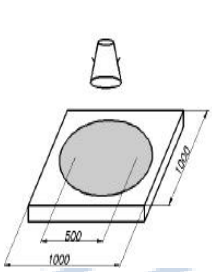
- Liquid = Na_2SiO_3 + NaOH
- Liquid / Binder = 0.5
- Na_2SiO_3 / NaOH = 2.0
- NaOH concentration = 8M
- Superplasticizer = Glenium Sky 8233 Poly Carboxylic-ether
- Retarders = Sucrose

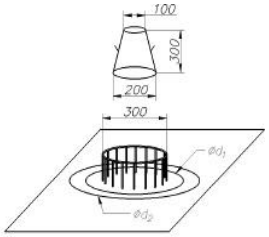
8. MIXING PROCESS:

The concrete mixing process consists of dry and wet mix. Initially, the pan mixer for solid components of SCGC, i.e GGBS, bottom ash, coarse aggregate, fine aggregate were mixed thoroughly for 2.5 minutes. At the end of the dry mixing the alkaline solution, super-plasticizers and retarders were added and the wet mixing done for 3 minutes. Chemicals such as SP and retarders have play an important role in increasing the workability and initial setting time of Self Compacting Concrete. The fresh concrete workability properties were performed for this project such as, slump flow, T_{50cm} slump flow, L-box, J-ring, V-funnel test methods.

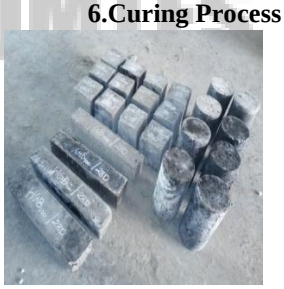
Fresh concrete properties of SCGC:

1.Slump flow **2.J-Ring**





3.V-funnel Test **4.L-Box Test** **5. Casting Of Test** **6.Curing Process**



7.Compressive strength test **8.Split tensile strength test** **9. Flexural strength test**

9. WORKABILITY TEST RESULTS:

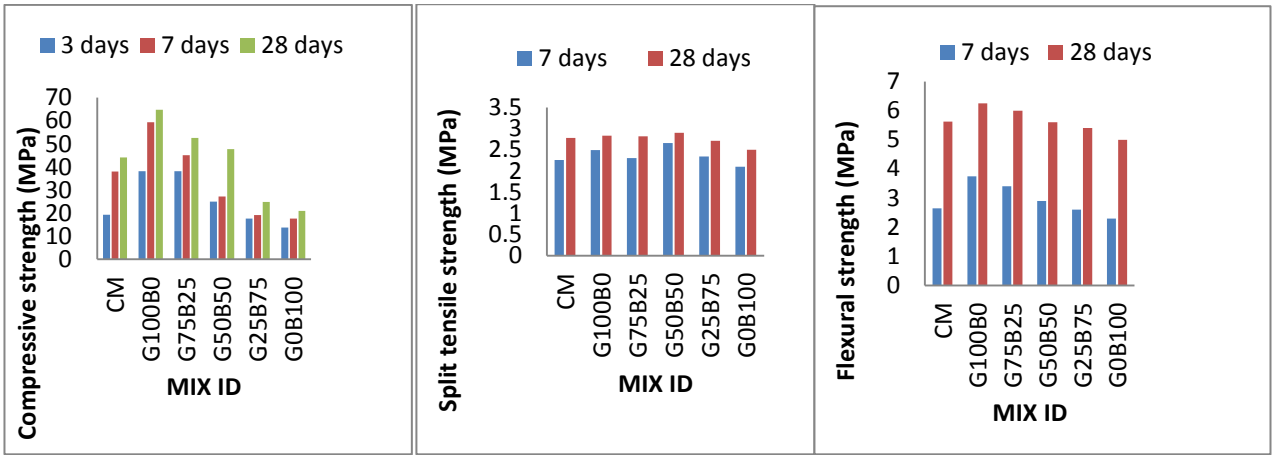
S.No	Mix ID	CM	$G_{100}B_0$	$G_{75}B_{25}$	$G_{50}B_{50}$	$G_{25}B_{75}$	G_0B_{100}	Acceptance criteria	
								Min	Max
1.	Slump flow (mm)	700	650	659	665	650	662	650	750
2.	T_{50cm} slump flow (sec)	3.1	4	5	6	5	4	2	5
3.	'J' Ring (mm)	6.5	6	5	4	5	4	0	10
4.	'V' Funnel (sec)	9.7	9	10	8	9	8	6	12
5.	'L' Box (H_2/H_1)	0.81	0.85	0.82	0.75	0.80	0.87	0.8	1

The results of the quantitative measurements and visual observations showed that freshly prepared concrete mix had good flow, filling and passing ability, and also produced desired results and were within the EFNARC range of SCC. All the mixes satisfies the guidelines given in EFNARC specifications.

10. HARDENED CONCRETE TEST RESULTS:

MIX ID	Compressive strength test results (MPa)			Split tensile strength test results (MPa)		Flexural strength test results (MPa)	
	Ambient curing			Ambient curing		Ambient curing	
	3 days	7 days	28 days	7 days	28 days	7 days	28 days
CM	19.2	38.0	44.1	2.26	2.78	2.65	5.63
$G_{100}B_0$	38.1	59.4	64.8	2.49	2.83	3.75	6.25
$G_{75}B_{25}$	38.2	45.1	52.6	2.30	2.82	3.40	6.00
$G_{50}B_{50}$	24.9	27.2	47.7	2.66	3.00	2.90	5.60
$G_{25}B_{75}$	17.6	19.1	24.8	2.34	2.71	2.60	5.40
G_0B_{100}	13.7	17.6	20.9	2.10	2.50	2.30	5.00

11. GRAPHICAL REPRESENTATION



12. RESULTS AND DISCUSSION:

From obtained test results the compressive strength results shows that $G_{100}B_0$ mix produces gradual increase of strength for 3, 7 & 28 days. Also the next sample $G_{75}B_{25}$ have replacement of 25% bottom ash and 75% of GGBS gives better increment of compressive strength of nearly 19.3%, but compared to the previous mix, the value decreased.

The same result will be produced in next three sample $G_{50}B_{50}$, $G_{25}B_{75}$ &G_0B_{100}. But comparing to both $G_{100}B_0$ & $G_{75}B_{25}$ the strength values decreases.

The increase in the bottom ash results in decrease of compressive strength.

The sample $G_{100}B_0$ contains 100% GGBS produces the maximum compressive strength upto 46.9% at 28 days when compared to the conventional concrete, which are curing at ambient condition.

13. CONCLUSION

The workability properties of passing, filling ability for the self compacting geopolymer concrete fulfilled the EFNARC guidelines.

Compressive strength, split tensile strength and flexural strength test are performed for the various mix proportions of GGBS:BOTTOM ASH G_{100} B_0, $G_{75}B_{25}$,$G_{50}B_{50}$,$G_{25}B_{75}$,G_0B_{100}.

The conventional mix of concrete having cement and fly ash as source material produced compressive strength of 44.10 MPa at the age of 28 days.

The result of $G_{75}B_{25}$ produced compressive strength up to 19.3% when compared with the other combinations and the same mix have split tensile strength of 1.44% and flexural value of 6.6% at 28 days ambient curing.

When increasing the bottom ash content in the mix, the compressive strength of the mix gets decreased.

When increasing the bottom ash content in the mix, the compressive strength of the mix gets decreased.

The mix $G_{100}B_0$ and $G_{75}B_{25}$ can be taken as optimum mix based on workability test and mechanical properties.

Modulus of elasticity and durability properties will be carried out for further progress of work.

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