Impact Factor-4.013 *e-ISSN: 2581-6667*
International Journal of Engineering and Creative Science, Vol. 4, No. 9, 2021
www.ijecs.net

Experimental Study on Properties of Self Compacting Concrete with Crushed Rock Dust and GGBS

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Abstract – *Self-compacting concrete (SCC) is a particular category of concrete and, due to the excellent deformation, is being mounted and reinforced itself under the weight even without vibration effort, while also being homogenous but need to be treated without separation or swelling. Adding GGBFS and Crushed rock dust gives a phenomenal strength to the concrete. In this paper, attempt is made the flow properties and mechanical properties of SCC are studied with different percentage of adding GGBS and Crushed rock dust .In that Crushed rock dust is replaced as fine aggregate at 0% ,10%,20% and 30% in that each associated mix the GGBS as a partial replacement for cement at 0% to 15%. The flow property values are maximum at the concentration of GGBFS and Crushed rock dust is 10% and the mechanical properties are getting maximum at the concentration of GGBFS and Crushed rock dust are 15% and 30% respectively.*

Keywords- ***Self-compacting concrete, Metakaolin, Forza super plasticizer, Fly Ash, GGBS, Crushed rock dust , NAN-SU method of mix design approach, Fresh properties, Hardened properties.***

I- INTRODUCTION

Self-compacting concrete was originally developed in Japan and Europe. It is a concrete that is able to flow and fill every part of the corner of the formwork, even in the presence of dense reinforcement, purely by means of own weight and without the need of for any vibration or other type of compaction. The growth of Self Compacting Concrete by Prof. H.Okamura in 1986 has caused a significant impact on the construction industry by overcoming some of the difficulties related to freshly prepared concrete. The SCC in fresh form reports numerous difficulties related to the skill of workers, density of reinforcement, type and configuration of a structural section, pump-ability, segregation resistance and, mostly compaction. The Self Consolidating Concrete, which is rich in fines content, is shown to be more lasting.

The work of Self Compacting Concrete is like to that of conventional concrete, comprising, binder, fine aggregate and coarse aggregates, water, fines and admixtures . To adjust the rheological properties of SCC from conventional concrete which is a remarkable difference, SCC should have more fines content, super plasticizers with viscosity modifying agents to some extent.

As compared to conventional concrete the benefits of SCC comprising more strength like non SCC, may be higher due to better compaction, similar tensile strength like non SCC, modulus of elasticity may be slightly lower because of higher paste, slightly higher creep due to paste, shrinkage as normal concrete, better bond strength, fire resistance similar as non SCC, durability better for better surface concrete.

Addition of more fines content and high water reducing admixtures make SCC more sensitive with reduced toughness and it designed and designated by concrete society that is why the use of SCC in a considerable way in making of pre-cast products, bridges, wall panels etc. also in some countries. In the present work Crushed rock dust is replaced as fine aggregate at 0%, 10%, 20% and 30% in that each associated mix the GGBS as a partial replacement for cement at 0% to 15%. Will be studied in Fresh and Hardened state.

II - MATERIAL AND MIX DESIGN

CEMENT

Ordinary Portland Cement (OPC) is the cement best suited to general concreting purposes. OPC 53 grade confirming with **IS: 12269**

properties of cement

Physical property	Normal Consistency	Vicat initial setting time	Vicat final setting time	Specific gravity
Obtained value	33%	105MINUTES	360MINUTES	3.15

FLY ASH

Fly ash is available in dry powder form and is procured from Vijayawada Thermal Power Station, ibrahimpatnam, Vijayawada. The light grey fly ash is available in 30 kg bags. The fly ash produced by the company satisfies all the requirements of the **IS: 3812-1981**.

Constituents	SiO_2	Al_2O_3	Un-burnt fuel	CaO	Mgo,So3
Percentage	30 –60	15-30	up to 30	1-7	Small amounts

SAND

Natural river sand has been collected from River and conforming to the Zone-II as per IS-383- 1970.

Type of aggregate	**Specific gravity**	**Bulk density(kg/m^{3})**
Fine aggregate	2.62	1596.4
Coarse aggregate	2.78	1494.11

COARSE AGGREGATE

Locally available crushed stone angular aggregate confirming to IS 383:1970 were used . The maximum size of aggregate is 12.5mm and specific gravity is 2.78 and bulk density value of coarse aggregate is 1494.11 kg/m^{3}.

GGBS

The main components of blast furnace slag are CaO (30-50%), SiO_2 (28-38%), Al_2O_3 (8-24%), and MgO (1-18%). In general increasing the CaO content of the slag results in raised slag basicity and an increase in compressive strength. The MgO and Al_2O_3 content show the same trend up to respectively 10-12% and 14%, beyond which no further improvement can be obtained. Several compositional ratios or so-called hydraulic indices have been used to correlate slag composition with hydraulic activity; the latter being mostly expressed as the binder strength.

METAKAOLIN

The particle size of metakaolin is smaller than cement particles, but not as fine as silica fume. Metakaolin in **concrete** tend to reduce the size of pores which consequently lead to obtain more strength, higher density, and more resistance to acid. Furthermore, metakaolin improves **concrete** resistance to alkali silicate reactions and sulfate attack. The uses of Metakaolin High performance, high strength, and lightweight concrete, Precast and poured-mold concrete, Fiber cement and Ferro cement products, Glass fiber reinforced concrete.

CRUSHED ROCK DUST

Crushed rock dust is a substitute of river sand for concrete construction. Crushed rock dust is produced from hard granite stone by crushing. The crushed sand is of cubical shape with grounded edge, washed and graded to as a construction material. The size of Crushed rock dust is less than 4.75mm.

Physical Properties of Crushed rock dust

S. No	Property	Results Obtained
		Crushed rock dust
1	Specific gravity	2.68
2	Bulk density (kg/m^{3})	1750

SUPER PLASTICIZER

The super plasticizer used in this study is Aramix super plasticizer (FORZA), HI-Bond super plasticizer (HI-245 SP). The Super plasticizers should bring about the required water reduction and fluidity but should also maintain its dispersing effect during the time required for transport and application. The required consistence retention will depend on the application. Precast concrete is likely to require a shorter retention time than for concrete that has to be transported to and placed on site.

III - EXPERIMENTAL INVESTIGATION ON SELF-COMPACTING CONCRETE

For casting the cubes, cylinder and beam specimens a standard cast iron metal moulds of size 100x100x100mm cubes and 100mm diameter 200mm height cylinder and beams of size 500mm long and 100mm height are used . In this study we are doing a different proportions of trial mixes are mentioned as below.

- The cement is partially replaced with GGBS @ 0%,5%,10% and 15%
- The natural sand is also replaced with crushed rock dust in terms of 10% , 20% andB3) and 30%.

In the mix designation notation, '**S**' stands for SCC mix, '**G**' stands for GGBS and '**R**' stands for crushed rock dust. The numerical value shows the percentage of replacement.

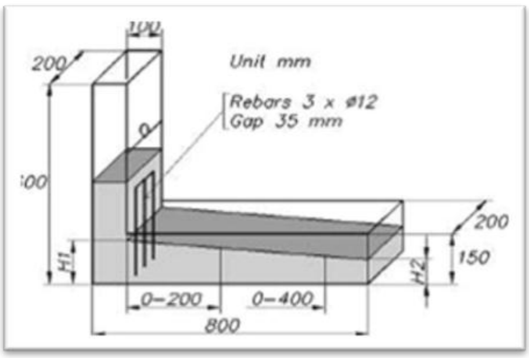
Mix proportions of various SCC mixes

Mix Designation	Cement	GGBS	Fly ash	Metakaolin	Coarse aggregate	Fine aggregate	Crushed Rock dust	Water	Super plasticizer
SG0R0	425	0	83.11	9.235	667.5	988.07	0	212.61	4.138
SG0R10	425	0	83.11	9.235	667.5	889.27	98.80	212.61	4.138
SG0R20	425	0	83.11	9.235	667.5	790.45	197.61	212.61	4.138
SG0R30	425	0	83.11	9.235	667.5	691.65	296.42	212.61	4.138
SG5R0	403.75	21.25	83.11	9.235	667.5	988.07	0	212.61	4.138
SG5R10	403.75	21.25	83.11	9.235	667.5	889.27	98.80	212.61	4.138
SG5R20	403.75	21.25	83.11	9.235	667.5	790.45	197.61	212.61	4.138
SG5R30	403.75	21.25	83.11	9.235	667.5	691.65	296.42	212.61	4.138
SG10R0	382.5	42.5	83.11	9.235	667.5	988.07	0	212.61	4.138
SG10R10	382.5	42.5	83.11	9.235	667.5	889.27	98.80	212.61	4.138
SG10R20	382.5	42.5	83.11	9.235	667.5	790.45	197.61	212.61	4.138
SG10R30	382.5	42.5	83.11	9.235	667.5	691.65	296.42	212.61	4.138
SG15R0	361.25	63.75	83.11	9.235	667.5	988.07	0	212.61	4.138
SG15R10	361.25	63.75	83.11	9.235	667.5	889.27	98.80	212.61	4.138
SG15R20	361.25	63.75	83.11	9.235	667.5	790.45	197.61	212.61	4.138
SG15R30	361.25	63.75	83.11	9.235	667.5	691.65	296.42	212.61	4.138

Slump flow equipment

Measuring diameter of spread (mm)

V-funnel equipment



L-box equipment

SPECIMENS IN CURING TANK

SG0R0 cube

SG0R10 cube

SG0R0 cylinder

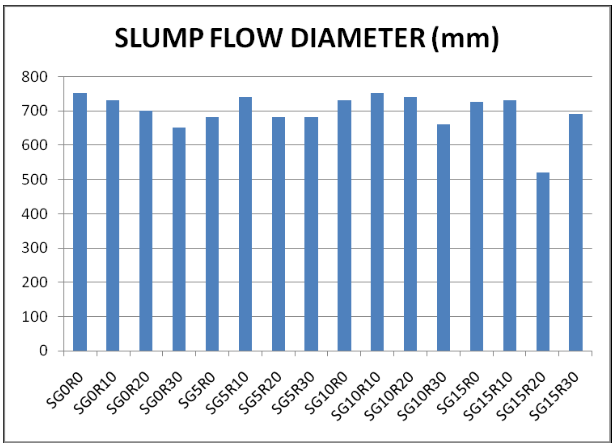
SG0R0 beam

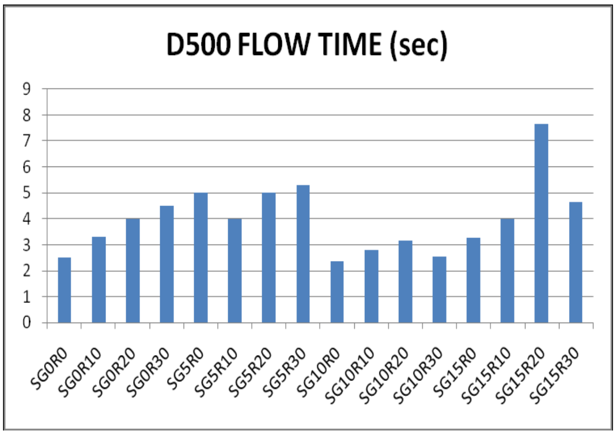
FAILURE PLANES OF DIFFERENT SPECIMENS UNDER UNIVERSAL TESTING MACHINE

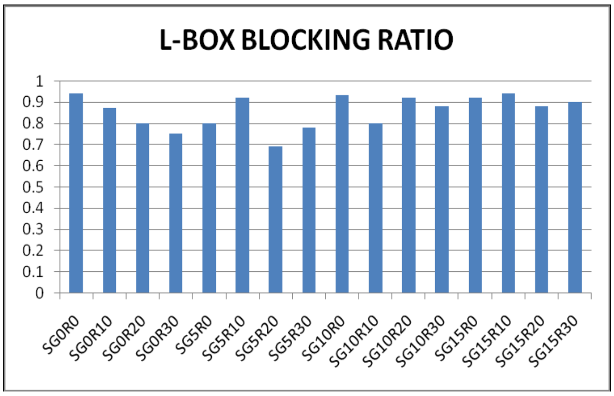
IV - RESULTS

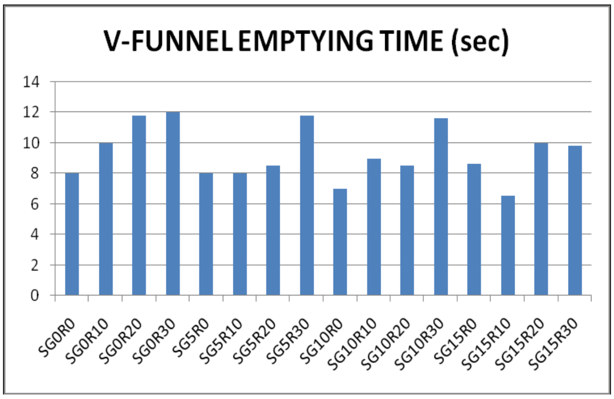
Flow properties for SCC Mixes

MIX DESIGNATION	SLUMP FLOW (650-800) mm	D500 FLOW TIME (2-5) sec	L-BOX BLOCKING RATIO (H2/H1) (0.8-1.0)	V-FUNNEL EMPTYING TIME (8-12) sec
SG0R0	750	2.5	0.94	8
SG0R10	730	3.3	0.87	10
SG0R20	700	4	0.8	11.8
SG0R30	650	4.5	0.75	12
SG5R0	680	5	0.8	8
SG5R10	740	4	0.92	8
SG5R20	680	5	0.69	8.5
SG5R30	680	5.3	0.78	11.8
SG10R0	730	2.35	0.93	7
SG10R10	750	2.8	0.8	9
SG10R20	740	3.15	0.92	8.5
SG10R30	660	2.54	0.88	11.62
SG15R0	725	3.25	0.92	8.64
SG15R10	730	4	0.94	6.56
SG15R20	520	7.64	0.88	10
SG15R30	690	4.64	0.9	9.8



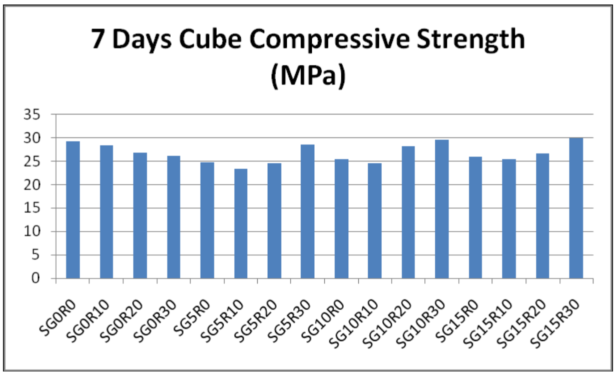


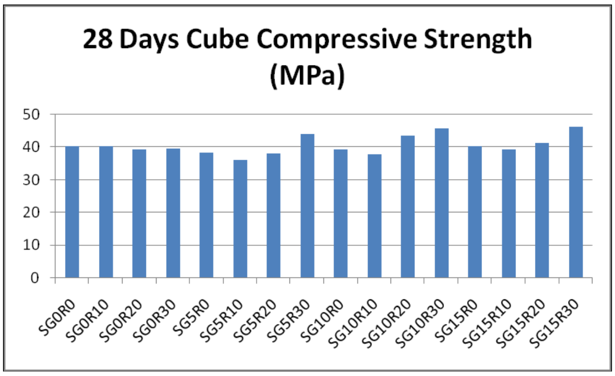


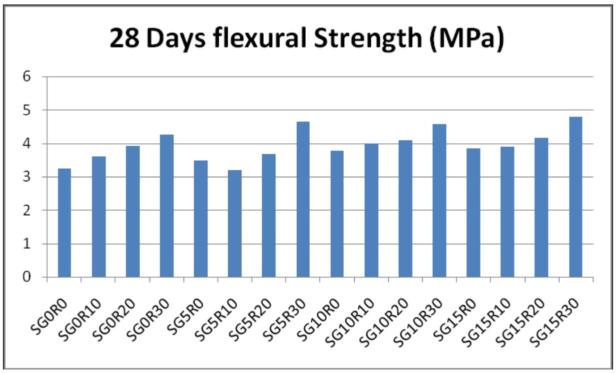


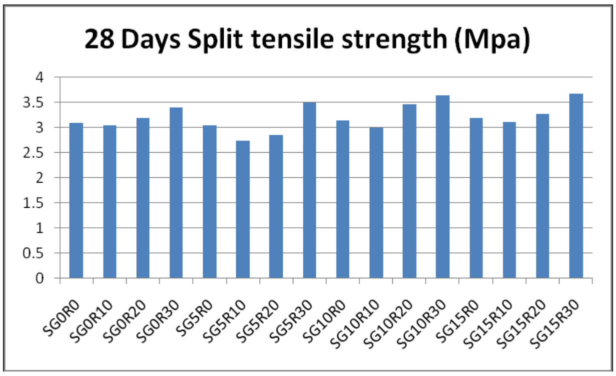
Compression strength values of SCC mixes

MIX DESIGNATION	28 Days Cube Compressive Strength (MPa)	7 Days Cube Compressive Strength (MPa)	28 Days flexural Strength (MPa)	28 Days Split tensile Strength (MPa)
SG0R0	40.20	29.25	3.25	3.1
SG0R10	40.12	28.35	3.60	3.05
SG0R20	39.25	26.8	3.93	3.2
SG0R30	39.36	26.15	4.25	3.4
SG5R0	38.19	24.82	3.48	3.05
SG5R10	35.88	23.32	3.2	2.75
SG5R20	37.82	24.58	3.68	2.86
SG5R30	43.88	28.52	4.64	3.5
SG10R0	39.28	25.53	3.78	3.14
SG10R10	37.79	24.56	4.0	3.0
SG10R20	43.40	28.21	4.08	3.47
SG10R30	45.68	29.69	4.58	3.65
SG15R0	40.10	26.05	3.85	3.2
SG15R10	39.24	25.50	3.9	3.12
SG15R20	41.06	26.68	4.16	3.28
SG15R30	46.01	29.90	4.8	3.68









V - CONCLUSION

- Slump flow is increasing at 10% of Crushed rock dust in SCC mixes as designated as SG0R10, SG5R10, SG10R10, and SG15R10 and after these mixes the slump flow is decreases as per the charts.
- In this mixes SG10R10, SG5R10 and SG10R20 shows better flow properties due the properties of CRD and GGBS than all the mixes.
- In all mixes mostly at 5% GGBS as cement replacement shows increase in flow properties but at 10%,15% GGBS as cement replacement shows lower value of blocking ratio. V-Funnel Emptying time is increasing in all different SCC mixes
- The increase Slump flow (D500mm) period increases in all different mixes but in SG15R0 mixes after SG15R20 SCC mix the time taken to cross the D500mm mark is decreases as per the table 5.1 and charts.
- The compressive strength of the cube is increasing using GGBS and CRD in associated mix compare to SC0R0 in that getting maximum value at SG15R30 SCC mix for both 7 and 28 days as per the table 5.2 and charts 6.
- The flexural and split tensile strength of the beam and cylinder are getting maximum values at SG15R30 SCC mix but small decrement in SG5R10 and SG5R20shown at respectively as per table 5.2 and charts 8.
- The fresh properties values of SCC mix are decreasing and mechanical properties are increasing when we increase GGBFS and Crushed rock dust percentages and vice-versa.

Acknowledgements: The authors are greatly acknowledged DST-FIST (Govt. of India) for funding to setting out the research computing facilities at R.V.R & J.C College of Engineering.

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[11] *T. G. Ushaa Mixtures were prepared with alkaline liquid to binder ratio by mass value is 0.33 for mix M1, M2, M3, M4, M5.The molarity of sodium hydroxide is 12M and replacement of fly ash by GGBFS of 30% is kept as constant for all mix. The ratio between sodium hydroxide to sodium silicate solution is 1:2.5. (2018).*

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[13] *ARABI N. S. ALQADI The results show that the method was adequate to proportion SCHPC mixtures containing ternary binders, i.e. cement and two different MAs (rice husk ash (RHA), silica fume, fly ash, and lime stone powder), satisfying the self-compactability requirements and compressive strength class in the range of C60/75 to C90/105,(2020.)*

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